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REPORT

ON THE

NEW RED

OF

Bucks and Montgomery Counties

BY

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PHILADELPHIA, PA.

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CONTENTS.

Page.

Name, ... 2589
    New Red, ... 2589
    Other Names, ... 2589
    Transitional, ... 2590
Situation, ... 2590
    Place, ... 2590
    Shape, ... 2591
Lay of the land, ... 2591
    Streams, ... 2591
    Hills, ... 2591
    Roads, ... 2592
    Towns, ... 2593
Geology, ... 2594
        Old ideas, ... 2594
        Cross-bedding, ... 2594
        Parallel faults, ... 2595
        Problems, ... 2595
    Structure, ... 2596
        Dip-record, ... 2596
        Accuracy, ... 2596
        Corroborations, ... 2597
        Strike-curves, ... 2598
        Dips in general, ... 2598
        Southern edge, ... 2598
        Great fault, ... 2598
        Northern part, ... 2599
        General structure, ... 2600
        Cause, ... 2600
        Divergent axes, ... 2601
        Northern hill, ... 2602
    Rocks, ... 2602
        Sedimentary, ... 2602
            Thickness, ... 2602
                Old ideas, ... 2602
                Dips in general, ... 2602
                Dips in detail, ... 2603
                Columnar sections, ... 2603
                Gaps computed, ... 2604
                Extent of computations, ... 2604
                Checks, ... 2605
                Fossil indications, ... 2605
            Sub-division, ... 2606
                Rogers' division, ... 2606
                Bed colors, ... 2606
                Sub-divisions, ... 2607
            Pottstown Shales, ... 2607
                Description, ... 2607
                Top, ... 2608
                Fossils, ... 2608
            Perkasie Shales, ... 2608
                Description, ... 2608

Page.

Fossils, 2609
Lansdale Shales, 2609
Description, 2609
Fossils, 2610
Gwynedd Shales, 2610
Description, 2610
Fossils, 2611
Age, 2611
Norristown Shales, 2612
Description, 2612
Fossils, 2612
Newark, 2613
Eastern, 2614
Age, 2614
New Red age, 2615
Not all mesozoic, 2615
In other States, 2615
Unpublished details, 2616
Trap, 2616
Deposits, 2616
Extent, 2616
Solid and broken, 2618
Areas, 2618
Northern, 2618
Eastern, 2619
Southern, 2619
Trenton Cut-off, 2620
Mode of occurrence, 2621
Overflows, 2621
Dikes, 2622
Age, 2623
Lithology, 2623
Diabase, 2624
Dolerite, 2624
Gabbro, 2625
Epidiorite, 2625
Economic Geology, 2626
Soil, 2626
Red shales, 2626
Dark shales, 2626
Trap, 2626
Building stone, 2627
Brownstone, 2627
Gray sandstone, 2627
Pebbly sandstone, 2628
Trap, 2628
Paving stones, 2628
Trap, 2628
Sandstone, 2628
Road metal, 2628
Coal, 2628
None workable, 2628
Gwynedd Shales, 2629
Neshaminy, 2629
Perkiomen, 2629
Elsewhere, 2630
Perkasie Shales, 2630
Oil, 2630
Lead, Zinc and Copper, 2631
New Galena mine, 2631
Perkiomen and Ecton mines, 2631
Phoenixville mines, 2631
A. Charles's copper, 2632
A. Kober's copper, 2632

Page.
J. Tettemer's copper, ... 2632
Gold, ... 2633
Umber, ... 2633
Water, ... 2634
Potomac Formation, ... 2634
Map, ... 2635
Two sheets, ... 2635
Houses omitted, ... 2636
Abbreviations, ... 2636
Color of contour lines, ... 2636
Topographical edition, ... 2636
Accuracy of reproduction, ... 2637
Acknowledgments, ... 2637

Report on the New Red of Bucks and Montgomery Counties

BY BENJAMIN SMITH LYMAN.

Illustrated by a Geological and Topographical Map and Four Cross-sections.

NAME.

The so-called New Red rocks of Bucks and Montgomery Counties were formerly named the New Red Sandstone, as if they were of the age of the British New Red and were chiefly sandstone. But perhaps hardly one-twentieth of the whole series is sandstone, and the rest are shales, much of them quite sandy, to be sure; and their age has long been universally admitted to be in the main different from the British rocks so named. The name, however, is commonly shortened to New Red, and, in case of any ambiguity, the prefix American readily disdistinguishes our beds from the British.

Other names, too, have been somewhat used, as, Older Mesozoic, Triassic, Jurassic, Triassico-Jurassic, and Jura-Trias; also Rhaetic, from the age of the fossils of a certain part of the rocks, as established by the able researches of Prof. W. M. Fontaine. Again, the name Connecticut Sandstone, has been proposed by Prof. C. H. Hitchcock, and well defended as a designation long in use among geologists. Furthermore, the name Newark System has been strongly recommended by Prof. I. C. Russell, and vigorously seconded by Mr. G. K. Gilbert, on the ground of priority (that excellent guide in default of better ones) as having been briefly proposed about forty years ago in a foot note to a paper by W. C. Red-field (Am. Jour, Sci., Vol. XXII, 1856, p. 357); though it was never accepted by geologists, and was long ago wholly forgotten, and in fact was in itself quite unsuitable, as will appear further on, and as has been partly explained in the Chicago Journal of Geology, 1894, p. 59. It will be seen later that none of the names indicating paleontological age, not even Older Mesozoic, will apply properly to the rocks in question. It may, then, not be altogether unpardonable, notwithstanding such eminent authorities, to designate the rocks here simply by the longest familiar and most readily understood expression, "New Red."

They were grouped together as the subject of a special survey and of this report under a universally prevalent, though, as we shall see, mistaken impression that they all belonged to one formation of narrowly restricted paleontological duration. The need or propriety of a single name to include all the beds is now in reality merely temporary, transitional, during the time it takes the geological public to become fully aware that the beds are not by any means of one closely limited paleontological period, nor even probably all Mesozoic, nor perhaps wholly distinct in their lower part from beds that occur in Western Pennsylvania, West Virginia and elsewhere associated with clearly Paleozoic formations.

SITUATION.

The two counties mainly fill the space between the Delaware and the Schuylkill from Philadelphia northward to the Durham and Reading Hills, the northeastern extension of the South Mountain; and the New Red covers the whole of the two counties, except a narrow strip of older rocks along the southern edge and another at the northernmost corner, and a small Paleozoic island, so to speak, about ten miles long and a mile or two wide, running southwestward from the middle of the Delaware river boundary.

The space, then, covered by the New Red is of a roughly triangular shape, with the apex towards the north on the Delaware, and the base somewhat bowed southward along the Schuylkill above Philadelphia; and with the straight boundary between the two counties running southeasterly somewhat south of the centre, so as to give more than half the field, rather rhomboidal in shape, to Bucks County.

LAY OF THE LAND.

The largest tributary stream within the counties is the Perkiomen, and it flows southward from the northern corner of Montgomery county to the middle of its southern boundary on the Schuylkill, with almost easterly flowing branches on the west and almost southerly flowing ones on the east. Stony Creek and the headwaters of the Wissahickon with southerly courses occupy the more eastern parts of the county. The northernmost of the eastern branches of the Perkiomen have their heads in the northern part of Bucks County; and from the same watershed flow down easterly the headwaters of Tohickon Creek towards the Delaware. The country south of the Tohickon is mainly drained by the Neshaminy Creek, with a southwesterly course to the Montgomery County line, and thence easterly again, and later southeasterly to the south edge of the field towards the Delaware. The hook-shape so formed in the upper part of the creek is the most striking result there is in this field, of the effect of the geological structure on the course of the larger streams.

The hills, however, generally in the eastern half of the field notably conform to that structure, and have in the main a northeasterly course, with some irregularities near the Delaware south of the Paleozoic "island." In the southern part of the western half, near the Schuylkill, there is something of the same regularity; but all the more northwestern parts of the field are much more irregular, in agreement with the geological structure there. The southern edge, and still more the northern one, is bounded by a higher rim of older rocks. The field itself is mostly low, but uneven, with no very extensive plains, and yet not with any uniformly rolling character. The height of the land is less than 300 feet above the sea along the southern edge of the field and near the two large rivers; but at a distance from them, rises on the whole gradually, so that most of the northern half and a small adjoining part of the southern half are more than 300 feet above the sea, and northward have here and there hills of 600 feet high, and even at one point, Haycock Mtn., over 900 feet above sea level. The shape of the surface shows in general, then, a decided conformity to the geological structure to be explained more fully further on, the harder beds standing out more or less prominently above the softer ones, and the whole not yet worn down to one level.

The common roads have mainly been laid out with great reference to the course of the hills, either parallel to them or squarely across them. Consequently the roads in the eastern and southern halves of the field usually run northeasterly and northwesterly, at right angles; occasioning too a similar arrangement of the boundary lines of the townships. But in the northwestern part of the field the arrangement of the roads and boundaries, like the hills, becomes much more confused; all owing, as we shall see, to the more complicated geological structure there. The railroads follow the Delaware (on the New Jersey shore), the Schuylkill, in great part on both shores, the Perkiomen, and Stony Creek (with a prolongation of several miles northeastward to Doylestown); and besides, the Bethlehem (or North Penn.) line runs across and through the hills northward just west of the centre of the field, and the Northeast Pennsylvania line likewise across the eastern corner of the field to New Hope on the Delaware, with the Newtown and Bound Brook lines still further southeastward. The numerous cuts along the railroads have been an important aid to the study of the geology of the field, though very far from exposing anything like a continuous section of all the rockbeds.

The largest town in the field is Norristown, the capital of Montgomery County, on the Schuylkill, a little west of the middle of the southern edge of the field, with Bridgeport, a large place, just across the river; and the second largest is Pottstown, also on the Schuylkill at the western end of the field. Doylestown, the capital of Bucks County, is within the peculiar hook-shape of the upper Neshaminy Creek already mentioned. Quakertown is on the Bethlehem line of railroad, in the midst of a rather wide basin-shaped plain near the middle of the northwestern edge of the field. Lansdale is an important town at the junction of the Stony Creek and Bethlehem lines of railroad; and North Wales is a couple of miles southward on the Bethlehem line, and Ambler four or five miles still further south; and Souderton and Telford five and six miles northward on the same line, and Sellersville and Perkasie four and five miles still further north upon it. Pennsburg and East Greenville form almost a continuous town on the Perkiomen Railroad near the northern corner of Montgomery County. Newtown is a town of importance inside the eastern corner of the field, and Yardleyville one at the eastern corner: Hatboro one on the Old York Road halfway between Newtown and Ambler; New Hope one on the Delaware near the end of the island-like patch of Paleozoic rocks; Oaks one at the mouth of the Perkiomen; Linfield, and Royersford two on the Schuylkill, five and seven miles southeastward of Pottstown; and Tylersport still another at three miles northwest of Telford. There is a very large number of other towns, many of them enterprising places, scattered pretty uniformly over the whole field, according to the agricultural capacities of the land: but none of them apparently with as many as 500 inhabitants in 1890.

GEOLOGY.

The geology of the field was formerly supposed to be in certain respects very simple, but in certain others very mysterious. The structure was taken to be in the main unvarying, with everywhere a northnorthwesterly dip of 10 to 25 degrees, averaging 15 to 20 degrees, and near the Delaware uniformly about 20 degrees (Rogers, State Geological Report of 1858, Vol. II, p. 670). The somewhat prevalent red color of the beds, together with their otherwise strong resemblance in great part and their conformity throughout and the general lack of fossils, had led not unnaturally to the widespread but, as we shall see, wholly erroneous conjecture that all the New Red beds both here and in the neighboring states, everywhere alike, belonged to a single quite limited paleontological formation; and that they consequently could not be, all together, of very great thickness, perhaps not more than 3,000 or 5,000 feet, as intimated, for example, by Dana. The conjecture from mere repetition became in the course of time generally accepted, because no economical or other reasons had occasioned any thorough investigation of the facts that would refute it. The mystery then was, how so small a thickness as that could cover a breadth of thirty miles or more with a uniform dip of 20 degrees. A simple computation showed that a dip of 20 degrees would give in such a breadth a thickness of about 55,000 feet; and that was recognized by Lesley as "clearly impossible" for a single formation (Report C 4 p. 180). Different explanations were suggested.

Rogers thought that the beds had originally been laid down on a sloping surface, so that the apparent dip was the result of false-bedding on a grand scale; and he considered the New Hope Paleozoic to be a part of the undisturbed floor of the beds that was exposed by denudation of moderate depth, and to be therefore proof that the whole New Red deposit was indeed only a shallow one. We shall see that a great fault at the southern edge of the paleozoic "island" destroys that proof. Against the false-bedding theory, it was conclusively objected by Hitchcock, in 1858, that the fossil footprints did not appear to have been made on an inclined surface; and by Cook, in 1886 and 1888, that not only the tracks and rain-drops had fallen on a level surface, but ripple-marks and flat-lying pebbles indicated the same level deposition, and the materials had come from the northwest as well as from the southeast; and by Newberry in 1888, that the numerous beds of thin-leaved shales, and the limestone beds must have been laid down in deep water horizontally.

Again, it was suggested that great parallel faults lengthwise of the formation with upthrow always to the northwest would bring the same beds repeatedly to the surface, and so require but a moderate total thickness. The thickness of the whole formation in York County was in that way thought by Dr. P. Frazer not very greatly to exceed 1,500 feet. Prof. Davis showed ingeniously and persuasively how such parallel faults might have arisen in Connecticut. The recurrence of similar-looking parallel hills of red beds of resembling material in New Jersey, pointed out by Cook, lent the theory some color, literally; but scarcely did more, as there was hardly any other observed fact to support the idea. For not only does a careful examination of extremely numerous exposures fail to show any important faults, though many trifling ones; but the complete working out of the geological structure, presently to be described, does not disclose more than a single large one, and even shows by the complicated structural irregularity through a great part of the field that long, straight parallel faults would be wholly incapable there of diminishing the total thickness required.

It is evident then that the present survey had to attack weighty problems, and that there was special need to be on guard against any bias from generally accepted opinions and undue influence from the great names or personal friendship of predecessors. The main questions were the geological structure and the columnar section, with the thickness of the formation and of its principal parts. The known fossils, if their stratigraphic relations could be ascertained, might give some indication of the age of the different sub-divisions of the columnar section. There was further some occasion to consider certain much disputed points in regard to the form of the deposits of trap-rock among the New Red beds. The economic geology, though of little importance compared with many other parts of the State, is not altogether insignificant; and especially a lack of geological investigation might easily give rise here to a great waste of money in fruitless attempts at mining.

STRUCTURE.

To ascertain the structure, a couple of thousand dips have been observed, recorded and plotted, covering satisfactorily every part of the field, and leaving no spaces between them so large as to make possible the existence of any important divergence from their indications. The dips are all marked in respect to their place, direction, amount and degree of certainty upon the printed map by a method that is somewhat unusual, but that has proved its extreme convenience and usefulness through more than twenty years' varied experience. Such numerous facts of that character could hardly have been clearly given upon a map of the same scale by any other method. The direction of the strike is shown conspicuously, as is desirable, by a one-barbed arrow; the barb shows which way the dip is; the angle of the barb shows the amount of the dip; the point shows where the dip was taken; a break in the lines shows rough measurement, and two breaks show greater uncertainty.

A careful inspection of the map and of the evident structure will readily and indisputably show that the observed dips are so near together as to make it perfectly safe in general to compute from them the thickness of the intervening unexposed beds; since the intermediate dips could not differ very materially within so short a space. Of course, in any one dip observation, there are manifold causes that may lead to an erroneous result. There may be, in the first place, a mistake in selecting the plane of inclination: For example, taking a cleavage plane or a false-bedding, or cross-bedding, plane, for the true plane of bedding; or not perceiving that the bedding plane, has been displaced from its proper position by "creep," or sliding down hill, or otherwise; and even if the right plane be taken, the line of greatest steepness for the dip, or of level for the strike, may be wrongly selected, especially where the dip is gentle or the bedding uneven. Or again, the angles may be misread; for instance, by mistaking the quadrant of the compass, or by counting the wrong way from the ten-degree marks of either the compass or the clinometer; or the clinometer may slip before it is read. But the map with its numerous dips shows that they mostly corroborate one another very well, and prove beyond a question the correctness of the structure inferred.

Furthermore, the structure indicated by the dips is confirmed by numerous cases of identification of beds at distant exposures through corresponding columnar sections and comparison of rock specimens, as well as in a general way by the color of the decomposed outcrops of the beds as shown in the roads and ploughed fields; and also by the topography of the surface. Advantage for that purpose was taken of the excellent topographical map with ten-foot contour lines made by Mr. Rudolph Hering and his assistants for the Philadelphia Water Department, and published in 1887 by the State Geological Survey, and covering the Perkiomen and Tohickon valleys, nearly one-half of the field of our map, and imagined to cover the whole field at the outset of our undertaking. The rest was filled out by less elaborate topographical work of the present survey, with aneroid levels and hasty sketching, and after the map was finished was partly replaced on the east by copying some newly published topography of the United States Geological Survey.

The structure is shown on the map by blue lines analogous to contour lines of the surface. The blue lines might be called equidistant strike-curves, and are curves one thousand feet apart in level, representing the position of the bottom of the five different sets of beds. Near the outcrop of the bottom of each set of beds, one blue line gives the sea level line of that bottom; the next line to the deep is one thousand feet below sea level; the next, two thousand feet; and so on. The distance of the lines apart shows, therefore, the steepness of the dip everywhere.

It is readily seen, then, that through a large part of the field the dips are indeed gentle northwesterly ones, as they were formerly supposed to be everywhere, and as they might well seem to be universally, if only looked at cursorily in traveling along the railroads and rivers. Yet, in other parts of the field, especially towards the northwestern border, and south of the Paleozoic near New Hope, it is obvious that the structure is much less simple through quite extensive spaces.

Even along the southern edge of the field the beds are far from lying in a monotonously uniform shape; but are gently, though on the whole very decidedly, waved, at least through the eastern half of that edge, with northerly dips of eight to fifteen degrees. Along the Schuylkill, however, there is much more uniformity, with gentle dips, eight to fifteen degrees, slightly west of north, all the way up to the neighborhood of Pottstown, where the irregularity of the northwestern border is visible. The gently wavy structure of the southern margin near the Delaware is followed northward by much irregular contortion, though generally without very steep dips, rarely more than twenty degrees, near the south side of the Paleozoic "island" and westward.

At the southern edge of the Paleozoic it is evident there is a very great fault, as was suspected by the late Prof. Henry Carvill Lewis and others without any complete demonstration. It is now clearly proved by the great differences in the horizons of the New Red that come together at the New Jersey end of the Paleozoic and at the western end near Doylestown; differences of about 14,000 feet there and 4,000 feet here. Prof. Lewis, however, did not have the opportunity of fully investigating the fault, and was under the mistaken impression that it had caused a heave (or horizontal dislocation) of four or five miles in a nearly vertical dike of trap. Also he mistook for confusedly broken fault-rock, as he supposed a hundred feet wide, certain dark shales in the railroad cut at Chalfont, west of Doylestown; shales that from one point of view, from the east, can be distinctly seen to be regularly bedded, though somewhat sharply folded and much fractured by numerous cleavages. Westward from the Paleozoic, the fault gradually dies out and disappears at a distance of about eighteen miles, but is replaced by a saddle or anticlinal in the rock-beds that continues northwestward to the limit of the field.

Southwest of the saddle, and between it and the neighborhood of Pottstown, the rock-beds form a deep basin, running northwesterly and containing the geologically highest rocks of the whole of the New Red of the two counties. The dips on the eastern side of the basin, near the edge of the field, not far from Boyertown, Berks County, gradually steepen to ninety degrees southwesterly, the only place where such steep dips have been observed in our New Red. In other parts of the basin the dips are generally much less steep, but on the two sides frequently as much as 25 or even 30 degrees. The country northeast from the saddle to the Delaware is filled by three shallow basins, with axes running northwesterly, and the middle one with a branch running northeasterly. The dips in these basins are mostly under 20 degrees, and in the central parts and in the easternmost basin down to eight degrees or less. Southeast of these eastern basins, as far as to the Paleozoic "island," the rock-beds lie very uniform, with gentle northwesterly dips of about ten or fifteen degrees.

It is noticeable, then, that along the northwestern edge of the two counties there are decided basins and saddles with axes at right angles to the general trend of the New Red and to the prevalent strike of the rest of the field; and that one of the saddles curving eastward becomes a great fault and bends northeastward along the southeastern edge of the Paleozoic "island," growing deeper and deeper all the way to the Delaware. It is striking, too, that both just south of this Paleozoic patch and along the northwestern edge of the field, in the two places, namely, where the fullest thickness of New Red rocks exists, the greatest contortion and irregularity of folding also occur. It is just in those places that the floor has sunk to the greatest depth, pressed down, no doubt into the underlying rocks, that must necessarily be plastic under the enormous weight of the immense thickness of beds. The same result is to be seen also northeastward, in New Jersey; and again in the Connecticut Valley, though here the thicker remaining part of the New Red is on the eastern side, owing to a more prevalent dip in that direction.

It is not clear at first view why the beds should have settled down to so great a depth mainly near the northwestern edge of the New Red in Pennsylvania and New Jersey, but near the eastern edge in Connecticut and Massachusetts, instead of along the middle line in both regions. It gives a one-sided appearance in both, as if, according to F. H. Bradley's and I. C. Russell's suggestion, the New Red had originally covered both regions continuously and much space adjoining, and the strip of country now between them had later been elevated, and the alternate regional halves of the New Red saddle so formed had afterwards been eroded with remarkable thoroughness. It is perhaps enough to suppose that, without so wide a former extent of the New Red, the depression took effect in each region near the side where there happened to be the least capacity for successful resistance. Possibly, indeed, the greatest thickness of beds and consequently the greatest pressure existed on that side of each region where now the greatest sinking has taken place. The greater thickness of beds in the deeper part of each may have been occasioned by the extent and steepness of the drainage of the adjacent ancient rivers and the character of the rocks they eroded.

The great diversity in the direction of the axes of the several rockfolds in the field, all presumably of contemporaneous formation, is of itself a refutation (if any were still needed) of the old ideas of the universal parallelism of axes of the same age, as if there were something of a crystallizing tendency in all the globe as a whole, with world-wide planes and great circle lines of activity. On the contrary, the folding would seem to have been guided simply by the lines of least and greatest resistance, by the thickness and cohesion of the beds folded, and by the prominence and firmness of the older ridges that could resist and bound the movement of the more recent rock-beds lying between them. The thickness and cohesion of the beds are of course determined by the shore line, currents and neighboring rivers of the sea of the time when the beds were deposited, and by the quantity and character of the eroded material brought down by the streams of that time. The prominence and firmness of the older ridges depend in the same way on the like conditions of an earlier period and on the subsequent folding of the ancient rock-beds then formed. The great axial directions, then, would roughly be some guide to the history of the outline of the seacoasts at different epochs. The axes of the folds of rock-beds might very well in any given region be parallel to more ancient axes of the same region, as, in a general way, they are in parts of these two counties. On the other hand, at short distances apart, axes of the same age might widely diverge, as they do in these two counties. This difference in the direction of the northern axes from the main ones seems likely to be due to the irregularity of the ancient shore line there, as shown particularly in the adjoining part of New Jersey.

A hill about a thousand feet high at the northern edge of the field and half a dozen miles from the northernmost corner of it was formerly supposed to be made up of New Red rocks, as mentioned in Report X, p. xxix; but it seems rather to consist of the quartzitic early Paleozoic sandrock called Chikis Sandstone, or No. I, which is here more or less reddish and covers the ground with a reddish hard gritty sand similar in color but different in character from the New Red materials.

Rocks.

The rocks of the field are chiefly sedimentary; but partly igneous, or trap. Let us first consider the sedimentary rocks.

Sedimentary Rocks.

It was formerly supposed, without particular investigation, that the total thickness of the New Red was everywhere the same; and it was far from being suspected, what now appears to be the fact, that the thickness existing in and near Montgomery County was decidedly greater than elsewhere. It has already been shown that although the total thickness had come to be generally accepted as some 3,000 or 5,000 feet, it was only so by mere repeated conjecture, or assumption, in the absence of any proof to the contrary; and that there was an equally substantial conjecture that it was only about 1,500 feet in York County, while the structure, so far as known, indicated about 55,000 feet near the Delaware. The uncertainty of the thickness, then, was very great, with absolutely nothing but conjectures in favor of any special figure between the limits of 1,500 and 55,000 feet. It is true, some geologists were surprised about ten years ago by a boring 3,000 feet deep near the lower edge of the New Red, at Northampton, Mass., and apparently passing through only a small part of the whole series of beds.

In our two counties, it is readily seen from the present map that the old estimate of the average steepness of the dip near the Delaware was too high at 20 degrees; so that, with the repetition of many beds on account of the great fault, and with the irregularities of structure south of it, the total thickness of the beds is much less than the 55,000 feet that the dip and the space covered formerly seemed to require. It is evident, too, that the total thickness of New Red along the Schuylkill, in Montgomery County, notwithstanding the much smaller breadth, is about the same as along the Delaware; and that the series of beds along the two rivers happen to be almost identical. But between the two rivers, several thousand feet of additional thickness occur both at the top and bottom of the column, owing to the deep basin north of Pottstown and the broad saddle, or anticlinical, east of Norristown.

Instead of taking in one simple estimate a breadth of thirty miles and seeing what thickness it would give for an assumed average dip, much more detailed measurements have been made. Indeed, any other course would have resulted in merely adding one more conjecture to the numerous old ones; and however accurate, it would have found no acceptance, on account of its differing, yet without demonstration, from the conjectures that had already gained general credence. It became necessary, therefore, for a result of any value whatever, to undertake much more thorough, laborious and time-consuming observations, notes, drawings and computations than would in ordinary cases have been worth while.

In addition to the couple of thousand dip observations recorded on the printed map, a couple of thousand separate rock exposures were carefully examined and noted as to the character of the beds, with about four thousand samples taken of the many varieties of rock, for the sake of subsequent comparison, and with measurement of the different layers; and the columnar section of each exposure was not only minutely noted in the field, but was drawn in the office to one uniform scale, to aid in the identification of beds at distant points. The exposures were many of them very large, including particularly all the cuts along the railroads and the cliffs along the rivers and the Neshaminy, besides the quarries and the exposures along more than half the roads that cross the strike nearly at right angles, as well as many other roads and streams.

Extensive as is the combination of all these special columnar sections there are many gaps between that are not filled by the beds of any observed exposures. The amount of those gaps therefore can obviously not be measured on the beds themselves, but must be estimated or computed in each case by the steepness of the dip and the distance from one exposure to the next adjacent one, taking account also of any difference there may be in the level of the exposures. The observed exposures are so numerous and so near one another and the dips in general so gentle in steepness and so uniform in direction, or so very gradually changing, that the inaccuracy of such a method of computation cannot be important. Moreover, any errors in estimating the dip in the gaps between exposures would be just as likely to be in excess as in diminution, and so would tend to balance one another. The result consequently for the whole columnar section is not likely to be very erroneous.

A sufficiently large number of the observed exposures have been made use of in the very laborious computation of the general section to insure an amply satisfactory result; though not by any means all of them were reckoned. Beginning at the upper end of the field on the Delaware (under the impression at first that the geologically highest beds would be there), the computation included all the observed exposures of the northwestern townships of the two counties and all along the Schuylkill, as well as most of the exposures near the west bank of the Delaware, and many others. More explicitly, the observed exposures made use of for the computations were all those of the following townships: Durham, Nockamixon, Tinicum, (nearly all), Springfield, Haycock, Richland, Rockhill, Milford, Upper Hanover, Douglass, New Hanover, Frederick, Pottsgrove, Limerick (nearly all), a full series along the Perkiomen and along the Schuylkill, including the Reading Railroad on both banks and the Pennsylvania Railroad on the east bank down to the southern edge of the New Red, and thence eastward to the Delaware, and all along the Delaware, and nearly all along the Neshaminy below Chalfont, and all along the Bethlehem, Stony Creek, Newtown and Bound Brook lines of railroad.

In many cases a small and sometimes a very large portion of the general columnar section was computed from exposures near one another along one route, and compared with the results of a like computation along another route, forming a polygon, and, after the detection of any errors, the small remaining difference was adjusted in each case in the way that seemed most reasonable; for example, by a slight steepening or lessening of the estimated dip between exposures, especially where the dip appeared least certain. The comparison of such duplicate portions of the whole column also required that there should be nothing inconsistent in the rock-beds that were found to occur in them at the same horizons. At many points where distant exposures were evidently on the same strike line it was possible to identify the beds through the similarity of the succession in both character and thickness, either by the descriptions noted in the field or by a comparison of the specimens collected.

It is plain that such close identification of layers at exposures several miles apart could in general never be made by means of fossils alone. For, in the most favorable case, a numerous assemblage of fossils of one kind in one thin layer represents the remains of something like a single school of fishes, or an oyster bed, or a bank of seaweed; and such collections of organisms of one kind would naturally be of limited extent, and might very well not be found persistent to a distance of several miles. So that, even, the presence of a similar mass of fossils of one kind at distant points would rather be presumptive evidence that the layers were not identical. On the other hand, the mere recurrence of a few scattered fossils of several kinds would not of itself conclusively identify a particular layer, because such kinds would be likely to have existed together throughout the deposition of many layers. Clearly, for a close identification of beds, fossils would be but a subordinate aid, and one only comparable at best to the lithological character of the layers.

It was found that the rock-beds were by no means of a wholly uniform character and color; as, indeed, had to some extent been understood long ago, though a departure from the more prevalent red color had sometimes been supposed to be mainly or solely due to alteration through the heat of neighboring igneous rocks. Rogers divided the New Red into three members: Upper and lower conglomerates of pebbles from adjacent older rocks in a red shale cement, and between the two, red shales and argillaceous red sandstones; yet in parts with dark colors and indurated shales, owing to trap-dikes near, or much igneous rock below the surface, particularly towards the Delaware and in northern York County. The conglomerate character, however, may be due merely to the proximity of the source of the pebbles, and may therefore occur in many horizons near the mouths of the rivers of the New Red time, though beds of the same horizons at a greater distance from the ancient shores may have a finer grained texture.

The dark color of some beds has been found to be due not to the neighborhood of trap, according to the old supposition, but to the color of their original materials unchanged by any baking. Such beds extend far and wide through the country, miles away from any trap or any evidence of the former existence of trap. With the blacker beds are sometimes associated thin layers of coal. Other rock beds are greenish, light green, or dark green, and some are very dark red, much darker than the common red beds. The striking differences have given a means of sub-dividing the whole New Red series into five sets of beds; and the scarcity of known fossils makes it hardly possible at present to suggest a better division. Perhaps in the course of time future discoveries of fossils may enable geologists to divide the series in another way; or at least to move the limits between these divisions up or down a little so as to conform better to paleontological requirements. The differences of color and character may indicate changes in the streams and currents and sediments of the New Red seas that corresponded to changes in the organic life of that time. At any rate, the strongly marked differences of color will give fixed points to measure from in adjusting any future discovered paleontological limits. In the main, the sub-division at present adopted is into two sets of hard, dark shales, with soft red shales above and below each set, and with the lower set of dark shales thicker, blacker and more carbonaceous than the upper one.

The whole series, so far as it occurs in Montgomery County, proves, then, to be at least about 27,000 feet thick; and to consist of the following five sub-divisions, beginning at the top: Shales, mostly soft and red, near Pottstown and northeastward, about 10,700 feet thick; shales, in great part hard and green, at the Perkasie tunnel and near it, about 2,000 feet; shales, mostly soft and red, at Lansdale and near it, about 4,700 feet; shales, in great part hard and very dark colored, at the Gwynedd and Phoenixville tunnels, about 3,500 feet; shales, mostly soft and red, at Norristown and eastward, about 6,100 feet.

Pottstown Shales.—The 10,700 feet in thickness of shales at Pottstown and northeastward are mainly soft and red and generally somewhat calcareous, with a few scattered green layers. There are also a few thin limestone beds about 4,000 feet above the bottom of this set of shales, and they are exposed near Pennsburg. Although most of the layers of the set are quite soft, there are numerous harder layers; scarcely any, however, very hard or of such thickness as to make important hills, in spite of rather numerous roadside exposures of thin somewhat firm beds. The space underlain by the shales is consequently for the most part rather flat, low-lying, fertile ground, except where beds of hard trap have protected the shales from erosion or have left them covered with scattered blocks, or where the very flatness has occasioned swampiness. Not only the immediate neighborhood of Pottstown, but the plains of the townships northeastward, Douglass, New Hanover, Frederick, Upper Hanover, and around Quakertown are illustrations of the topographical effect and of the general softness and fertility of this set of shales. The lower part of them also shows a little near Kintnersville and Monroe on the Delaware; but is much covered with trap blocks and decomposed trap earth.

The geologically highest beds of the field occur at about the middle of the northwestern boundary line of Montgomery County, a mile and a half northeast of Boyertown, Berks County. Whether still higher New Red beds occur in Berks County is not known; but probably there is no very great additional thickness of them.

The Pottstown Shales are not well suited to preserve fossils; but a few small very imperfect plant remains have been found in them within our field. The only recorded fossil from them anywhere is the Clepsysaurus Pennsylvanicus, Lea (Journal Acad. Nat. Sci., 1883, p. 185), from Upper Milford township, Lehigh County, just outside the northern corner of Montgomery County, and apparently about 5,000 feet above the bottom of them. It would seem to be insufficient to determine the age of the beds with any precision. As there are among the red shales some beds of green shales here and there apparently better fitted for preserving organic remains, there is reason to hope that fossils may some day be found more abundantly and of a character better capable of determining the paleontological age of the beds.

Perkasie Shales.—About 2,000 feet in thickness of the beds next below, occurring near the Perkasie tunnel, are mostly green and dark red or gray, rather hard shales, with several quite blackish perhaps even coaly layers. Owing to comparative hardness the shales form a generally well marked ridge from the Delaware, near Milford, N. J., and Uhlerstown, opposite, in Bucks County, round Stony Point and Bucksville, past Ottsville, south of the Haycock Mountain, over the Perkasie tunnel, to Tylersport, and in somewhat devious course past Sumneytown and Harleysville, to Lederachsville, and thence straight, south of Shwenksville, to Sanatoga, on the Schuylkill. The individuality of the ridge is in some parts obscured by the proximity of trap hills, and by the strong curves in its own course, the occasion probably of some breaking up of the beds and of more easy crosscutting with small valleys. The roads and ploughed land over these shales are generally of a slightly greenish gray color.

The firmer character of the beds has enabled a better preservation of fossil traces; though not many have yet been discovered within the two counties. But just across the Delaware, at Smith Clark's quarry, near Milford, N. J., plant remains and tracks of reptiles, and insects have been found among the layers of these shales, and have been recorded by Newberry, four plants (U. S. Geol. Mon. XIV), H. C. Lewis, one plant (Ac. Nat. Sci. Proc. 1880), and C. H. Hitchcock, fourteen tracks, (Boston Nat. Hist. Soc. Proc. Vol. XXIV). Cook (N. J. State Geol. Report, 1879), says that though vegetable impressions are found there "in large numbers, * * * * most of them are fragmentary and indistinct," but that "they are evidently much newer than the fossils at Newark and Belleville,"—that is, some 9,000 feet geologically lower, in our Norristown shales. The plants mentioned by Newberry, few and imperfect as they were, would seem rather to show that the shales are Jurassic. No more definite indication of the age of the beds appears to have yet been found in New Jersey, and no fossils at all in this set of beds have been recorded anywhere else.

Lansdale Shales.—The next lower 4,700 feet, or so, in thickness of rock beds, are chiefly red, in great part calcareous, shales with a few scattered green layers, and with a few small rather soft red sandrock layers exposed near the Schuylkill. The beds are mostly soft and generally do not form prominent hills; and exposures at the roadside are comparatively few, decidedly fewer than in the Pottstown Shales. The Lansdale Shales underlie a broad belt of country from Uhlerstown and Erwinna, on the Delaware, past Dublin, Telford and Souderton, and round by Hatfield, Lansdale, Kulpsville, Skippackville, Collegeville and Trappe to Royersford, on the Schuylkill; generally a region of gentle slopes, except where cut down deeply by the streams near the Delaware. There is also a small area of these shales south of New Hope, around Solebury and Jericho Mountains.

The beds are not favorable to the preservation of fossils, and scarcely any such traces have been observed within the present field. In York County, however, the Algae reported by Mr. A. Wanner, (State Geol. Report for 1887) and the tracks identified by Prof. C. H. Hitchcock (Boston Nat. Hist. Soc. Proc. XXIV), from a mile south of Goldsboro, occur perhaps towards the top of this set of beds. In New Jersey, too, one fish, at Pompton Furnace, recorded by Newberry (Mon. XIV), twelve tracks near Whitehall, identified by Prof. C. H. Hitchcock (B. N. H. Proc. XXIV), as well as plants, fishes, Estheriae and perhaps Cypris, mentioned, but not specifically, by Mr. F. L. Nason (N. J. Geol. Report, 1888), at several points, would seem probably to come from this set of beds. But none of all the fossils appears to give anything like a precise indication of the age of the beds.

Gwynedd Shales.—The next underlying 3,500 feet, or thereabouts, in thickness of beds are mostly dark red, particularly in the upper parts, dark green, dark gray and partly black shales, with even a little coal here and there. They are generally rather hard, and often very hard; and consequently form a prominent hill, or in many places two parallel hills, ranging through the field from Point Pleasant, on the Delaware, past Gardenville, Danborough, Fountainville to the great fault near Chalfont. South of the Paleozoic "island," the same shales also occur, and run from the upper edge of Lower

Makefield Township on the Delaware, past Dolington, Wrightstown, Forks of the Neshaminy, up the main Neshaminy Creek to Chalfont, and then over Gwynedd tunnel and cut, and thence straight to the Phoenixville tunnels. Owing to the double occurrence of the shales towards the Delaware, in consequence of the great fault, the general form of their outcrop in this field is that of a letter Y, with the foot on the Schuylkill.

The shales are in part well fitted to preserve fossil traces, and it is from this set of beds alone that have come almost all, if not quite all, the fossils that have indicated the Rhaetic, or Triassic, or Jurassic age of the American New Red. In our field, however, few fossils have been reported; and those few from two places, each about 1,000 feet geologically below the top of the set; namely at the Gwynedd tunnel: Turseodus acutus, Eurydorus serridens (?), Cypris, and batrachian bones and teeth (Leidy, Ac. Nat. Sci. Proc. 1857 and 1859), Radiolepis speciosus, Emm. (Lea. Do. Do. 1857), Rhabdopelix longisipinis, Cope (Am. Phil. Soc. Trans., 1868); and near Yerkes Station: Radiolepis elegans, Emm. (Leidy, A. N. S. Proc. 1876). But a much larger number of species have been reported from about the same horizon at the Reading Railroad tunnel near Phoenixville, and a few from some 500 feet geologically lower at the Pennsylvania Railroad tunnel near the same town. Very many fossil plants, fishes, reptiles and tracks as well as Estheriae and Cypris have been recorded as occurring in rocks evidently of this set of beds elsewhere, particularly in the Richmond, Va., coal field and the North Carolina coal fields, as well as a very few in York county, Pa., and eastward in New Jersey, and in Connecticut and Massachusetts.

The plants seem to have given more precise indications of the age of the beds than the other fossils have. Prof. Fontaine enumerates 67 species of plants found in the Virginia and North Carolina exposures. He argues that they indicate the Rhaetic age of the beds; for 23 are near or allied to foreign Rhaetic ones, and 14 to foreign Jurassic ones, and the rest are peculiar to America. Four of those counted as Rhaetic are also near or allied to foreign Triassic forms. The Rhaetic is regarded as forming beds of passage between the Trias and the Lias; but in Newberry's opinion (1888) "with a still prevailing Triassic facies," though in Fontaine's (1883), "having more affinity with the Lower Lias."

Norristown Shales.—About 6,100 feet in thickness next below, and the lowest rock-beds of the whole New Red column, are mostly red partly calcareous shales, but with some important, though comparatively thin, beds of brown building stone near the top, and several thicker, coarser and even pebbly beds of light gray hard sandrock lower down. The beds, however, are mainly soft shales, and the hills formed by the harder layers are not important. The group is partially exposed on the Delaware at Lumberville, Lumberton and southward to Limeport; and runs southwestward past Doylestown to the great fault. It also appears on the Delaware near Yardleyville, and runs through Newtown and Northampton Townships to Southampton, where its lowest beds occur, and past Hartsville, Hatboro, Ambler and Fort Washington to Norristown; and beyond the Schuylkill to King of Prussia, Valley Forge and past the southern outskirts of Phoenixville.

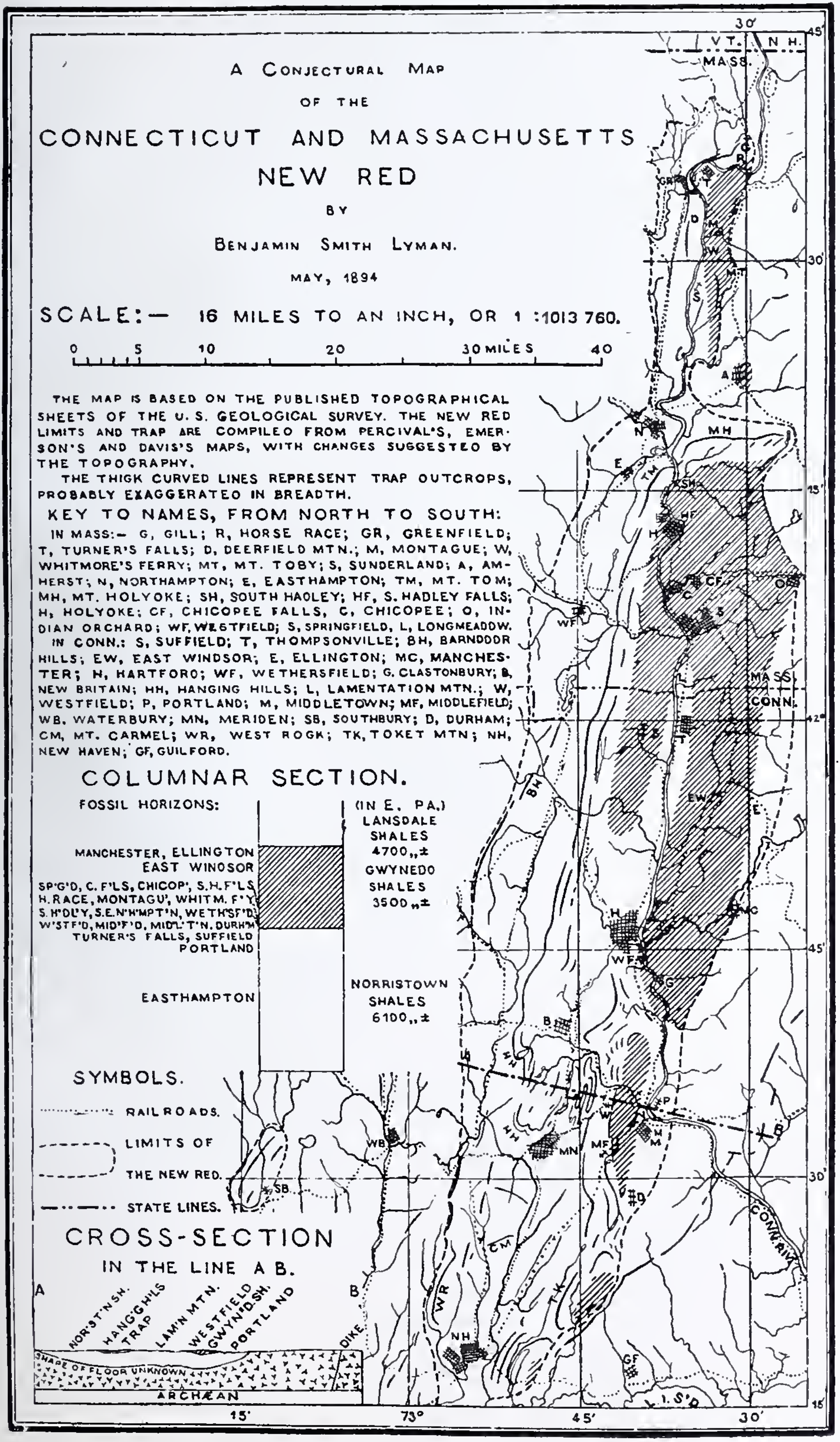
Few fossils have been found in this set of beds, owing to its character unfavorable to the preservation of organic remains. But, several years ago, at about 3,000 feet below the top, at Greenville, four miles and a half northeasterly from Doylestown, just north of the Paleozoic "island," Mr. John S. Ash found certain calamite fossils, as they appear; and by Mr. S. Edward Paschall, then dwelling at Doylestown, they were brought to the notice of Prof. H. Carvill Lewis, who thought they might be Calamites of Permian age. Mr. Ash with much pains succeeded in finding a specimen with two joints and the whole internode between, some twelve or fifteen inches long and eight inches or more broad, in hopes of having the specimens determined by so competent an authority as Lesquereux, then living; but apparently that result was never reached. Mr. Paschall has a less perfect fragment ten inches long and at least six inches broad with a single joint at two inches from one end; and he says there are better specimens at the Philadelphia Academy of Natural Sciences.

About 3,500 feet below the top of this set of shales, both at Fort Washington and below Norristown, undetermined plant fossils were found by Prof. Heilprin's geological class in the spring of 1894. Imperfect plant fossils were found during our survey at other points.

In evidently the same set of rock-beds, and near their top, at the quarries of Newark and Belleville, New Jersey, fossil plants have been found. Cook, in his New Jersey State Geological Report for 1879, says that photographs of one of them that had "a very plainly marked flattened stem" were sent to Lesquereux. That celebrated fossil botanist answered that the photographs were "sufficient at least for positive reference of the specimens to Lepidodendron;" and he was strongly inclined to identify them with L. Weltheimianum Presl., a leading species of the Old Red Sandstone and occurring from the sub-carboniferous measures down to the Devonian, while no Lepidodendron had hitherto been found as high as the upper coal measures. Newberry (Mon. XIV), speaks perhaps of the same plant when he says a fossil tree trunk often found in the Newark quarries resembles Lepidodendron, but cannot be one, because "Lepidodendron did not pass from the Carboniferous to the Mesozoic age;" evidently taking the Mesozoic age for granted in advance. The only other identified fossils from those quarries are two plants that he mentions in the same monograph: Dioonites longifolius and fragments of Clathropteris platyphylla, both found by Fontaine in the North Carolina and Virginia representatives of our Gwynedd Shales, and reckoned by him as probably nearly allied to certain plants of Jurassic age. Newberry also mentions an imperfect fossil at Newark resembling Equisetum Meriani, but too doubtful to decide whether it is a Calamites or Equisetum or of some other genus of that family. He mentions in the same monograph a fossil plant, undistinguishable from Dendrophycus Desori Lesq., as found in the brown sandstone quarries of Portland, Ct., no doubt of the same horizon as the Newark quarries. The plant of that name, however, is found in the Mauch Chunk Shales, Pennsylvania No. XI, or Umbral Shales, quite below the coal measures.

According to Newberry (Mon. XIV), the plant Clathropteris platyphylla is likewise found at Easthampton, Mass., and that must apparently be in the upper part of this set of beds. A fish fossil, his Ischypterus Braunii, was found at Weehawken, N. J., probably near the bottom of the same beds. Several Estheriae and imperfect fish and plant remains have been found at other places in New Jersey in beds most likely of the same set; and in Massachusetts and Connecticut, perhaps near the top of the set (or possibly in the Gwynedd shales) a great number of fossil foot-prints and a few unidentified plant remains have been reported by the elder Hitchcock.

It is clear, then, that the paleontological age of this set of beds has never been satisfactorily determined; and that there is a strong probability that they are Paleozoic, at least as old as the Permian. The Canadian geologists Ells (1882-4, 1885) and Fletcher (1886, 1890-91) in the Canada Geological Survey Reports, have stated that much of what was formerly called Trias in Prince Edward Island, New Brunswick and Nova Scotia is really Permian, Permo-carboniferous or even Carboniferous; for example, Permian up to 5,000 and 8,000 feet in thickness. It would be strange if no traces of such a great thickness of beds were found in the eastern United States near any of the Mesozoic rocks it is so closely connected with in the British provinces. It is intimately associated with the other New Red beds still reckoned as Mesozoic that appear to be identical with our New Red, and it would seem very natural, to say the least, that it should occur with them here. Profs. W. M. Fontaine and I. C. White have shown the existence of Permian beds in



A CONJECTURAL MAP
OF THE
CONNECTICUT AND MASSACHUSETTS
NEW RED
BY
BENJAMIN SMITH LYMAN.
MAY, 1894

SCALE:— 16 MILES TO AN INCH, OR 1 :1013 760.

THE MAP IS BASED ON THE PUBLISHED TOPOGRAPHICAL SHEETS OF THE U. S. GEOLOGICAL SURVEY. THE NEW RED LIMITS AND TRAP ARE COMPILED FROM PERCIVAL'S, EMERSON'S AND DAVIS'S MAPS, WITH CHANGES SUGGESTED BY THE TOPOGRAPHY.

THE THICK CURVED LINES REPRESENT TRAP OUTCROPS, PROBABLY EXAGGERATED IN BREADTH.

KEY TO NAMES, FROM NORTH TO SOUTH:

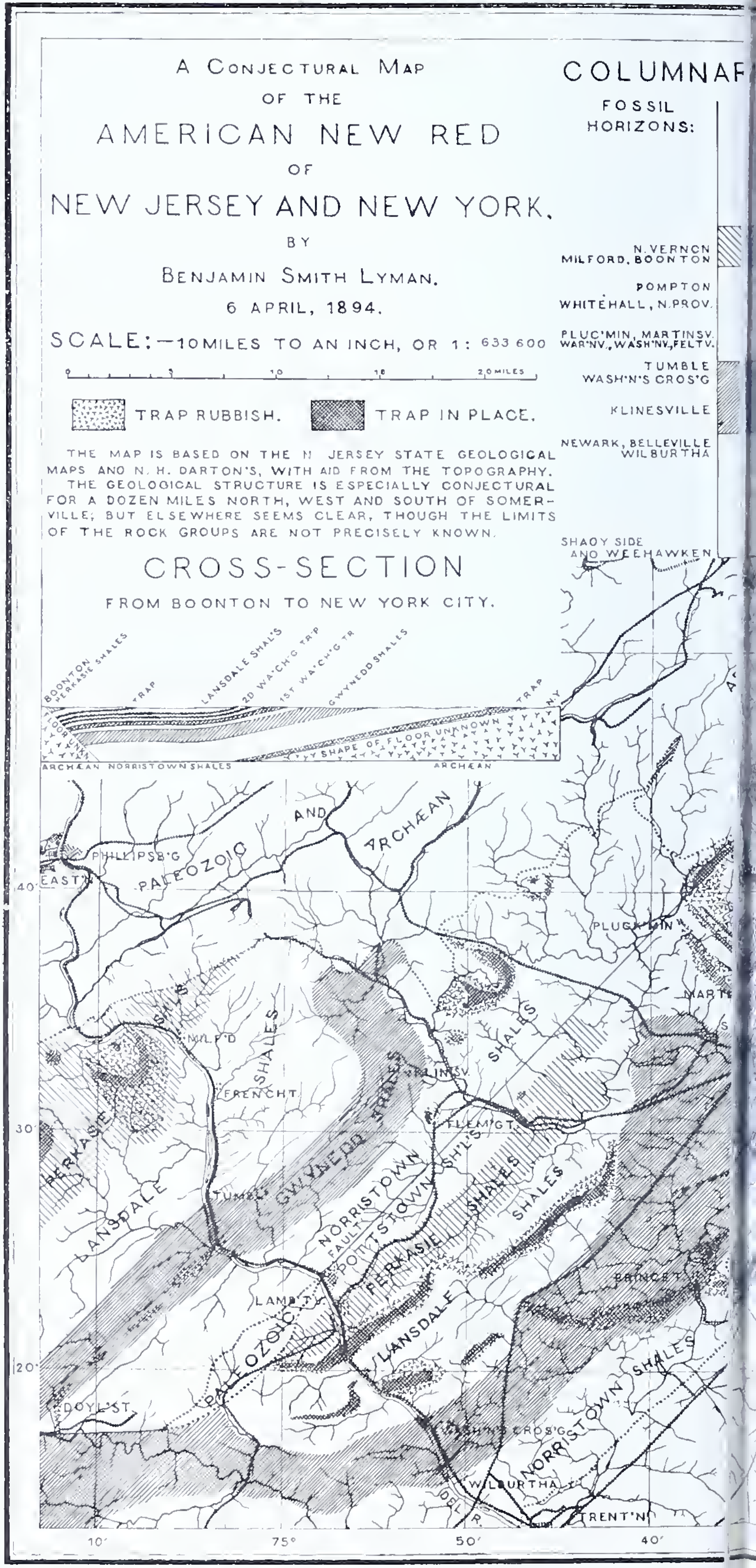
IN MASS:— G, GILL; R, HORSE RACE; GR, GREENFIELD; T, TURNER'S FALLS; D, DEERFIELD MTN.; M, MONTAGUE; W, WHITMORE'S FERRY; MT, MT. TOBY; S, SUNDERLAND; A, AMHERST; N, NORTHAMPTON; E, EASTHAMPTON; TM, MT. TOM; MH, MT. HOLYOKE; SH, SOUTH HADLEY; HF, S. HADLEY FALLS; H, HOLYOKE; CF, CHICOPEE FALLS, C, CHICOPEE; O, INDIAN ORCHARD; WF, WESTFIELD; S, SPRINGFIELD, L, LONGMEADOW.

IN CONN.: S, SUFFIELD; T, THOMPSONVILLE; BH, BARNDOOR HILLS; EW, EAST WINDSOR; E, ELLINGTON; MC, MANCHESTER; H, HARTFORD; WF, WETHERSFIELD; G, GLASTONBURY; B, NEW BRITAIN; HH, HANGING HILLS; L, LAMENTATION MTN.; W, WESTFIELD; P, PORTLAND; M, MIDDLETOWN; MF, MIDDLEFIELD; WB, WATERBURY; MN, MERIDEN; SB, SOUTHBURY; D, DURHAM; CM, MT. CARMEL; WR, WEST ROCK; TK, TOKET MTN; NH, NEW HAVEN; GF, GUILFORD.

COLUMNAR SECTION.

SYMBOLS.

CROSS-SECTION
IN THE LINE A B.



A CONJECTURAL MAP
OF THE
AMERICAN NEW RED
OF
NEW JERSEY AND NEW YORK,
BY
BENJAMIN SMITH LYMAN.
6 APRIL, 1894.

SCALE:—10 MILES TO AN INCH, OR 1: 633 600

▨ TRAP RUBBISH. ▩ TRAP IN PLACE.

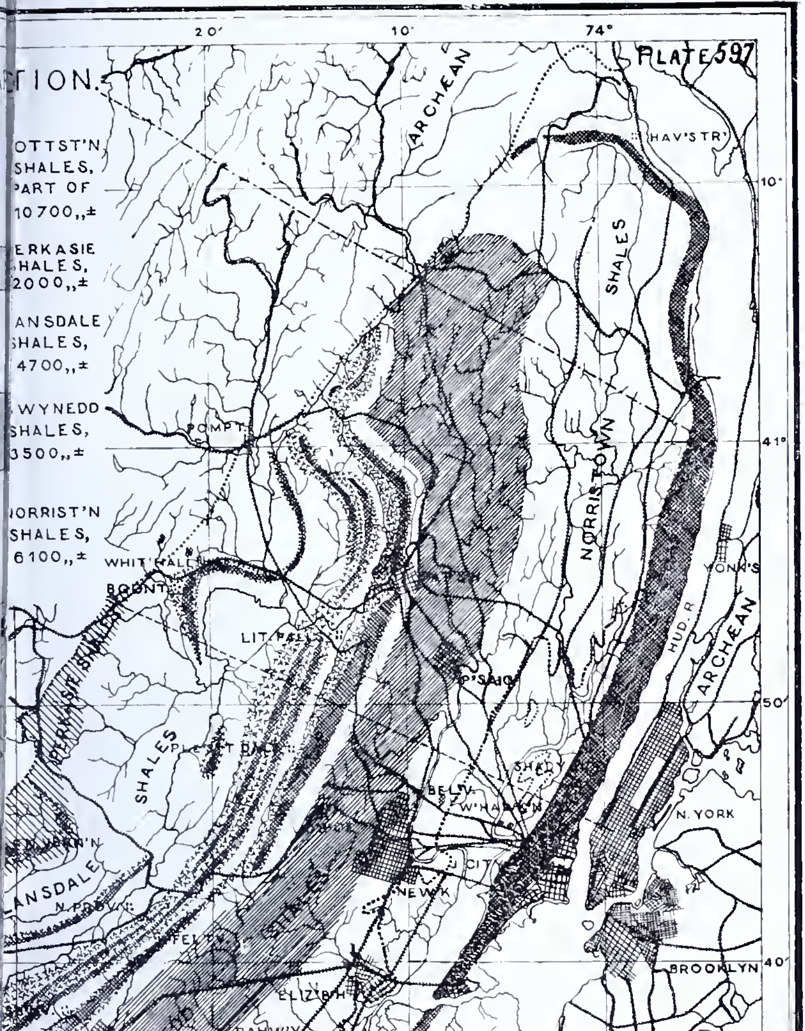
THE MAP IS BASED ON THE N JERSEY STATE GEOLOGICAL MAPS AND N. H. DARTON'S, WITH AID FROM THE TOPOGRAPHY.

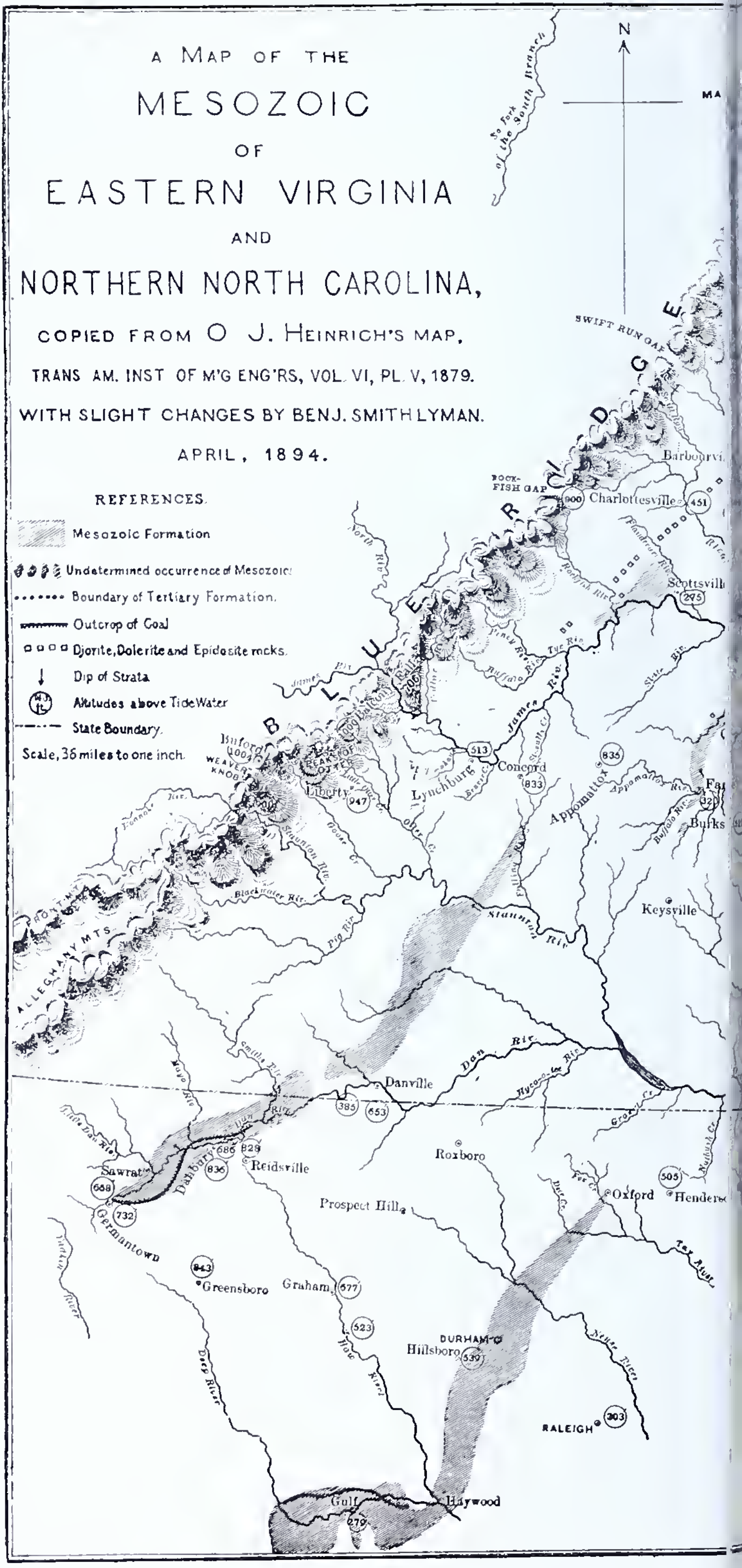
THE GEOLOGICAL STRUCTURE IS ESPECIALLY CONJECTURAL FOR A DOZEN MILES NORTH, WEST AND SOUTH OF SOMERVILLE; BUT ELSEWHERE SEEMS CLEAR, THOUGH THE LIMITS OF THE ROCK GROUPS ARE NOT PRECISELY KNOWN.

CROSS-SECTION
FROM BOONTON TO NEW YORK CITY.

COLUMNAR

PLATE 597


TION.
OTTST'N
SHALES,
PART OF
10700,,±
ERKASIE
SHALES,
2000,,±
ANSDALE
SHALES,
4700,,±
WYNEDD
SHALES,
3500,,±
NORRIST'N
SHALES,
6100,,±
20′
10′
74°
10′
41°
50′
40′
30′
20′
30′
20′
10′
74°
ARCHÆAN
HAV'STR'
SHALES
NORRISTOWN
POMPT.
WHIT'HALL
BOONT.
LIT. FALL
P'S'AIC
YONK'S
HUD. R.
ARCHÆAN
SHALES
PLE'S'T DALE
BEL'V.
W'HA'K'N
SHALES
N. YORK
J. CITY
NEW'K
LANSDALE
N. PRO.
BROOKLYN
ELIZ'B'H
RAH'W'Y
PLAINF'D
GWYNEDD SHALES
STATEN ISL'D
ATLANTIC
N. BRUNSW'K
RARIT. R.
AMBOY
SANDY
HOOK
CRETACEOUS
JAMESB.
LONG
BR'CH
FREEH'D



A MAP OF THE

MESOZOIC

OF

EASTERN VIRGINIA

AND

NORTHERN NORTH CAROLINA,

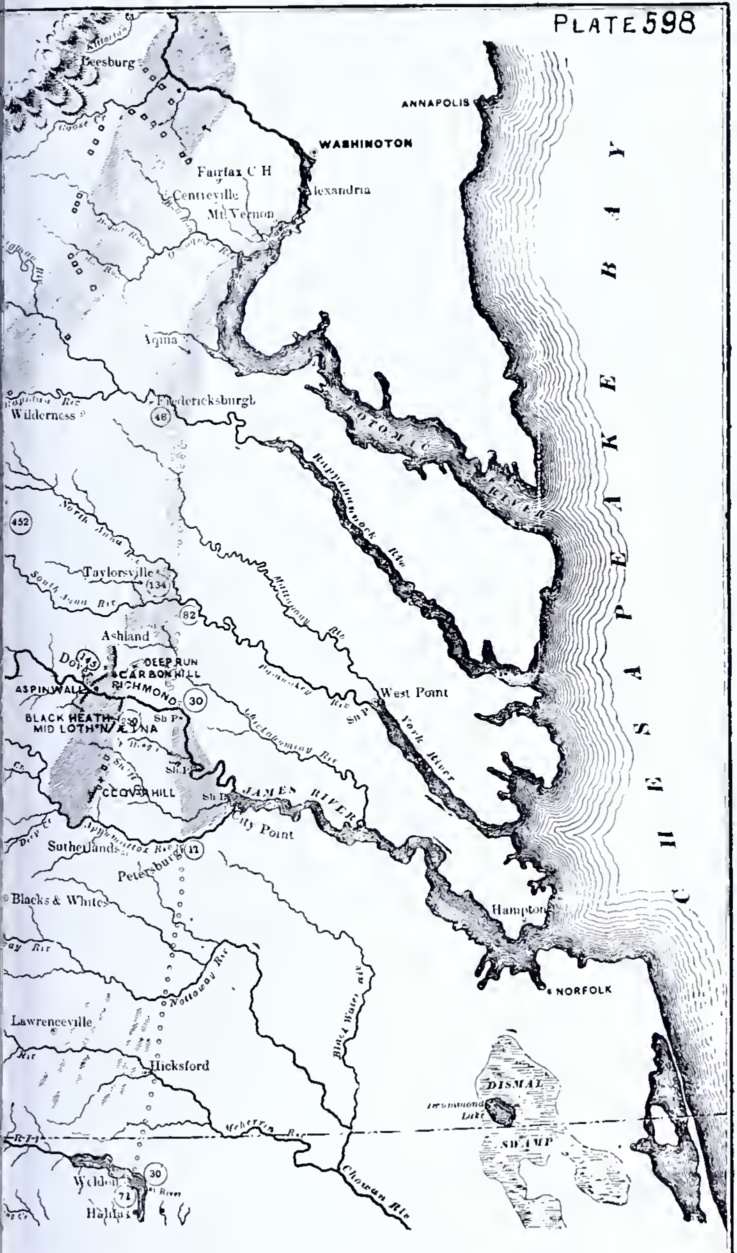
COPIED FROM O. J. HEINRICH'S MAP,

TRANS. AM. INST. OF M'G ENG'RS, VOL. VI, PL. V, 1879.

WITH SLIGHT CHANGES BY BENJ. SMITH LYMAN.

APRIL, 1894.

PLATE 598



NOTE BY B S L — FROM THIS MAP AND PROF. FONTAINE'S ACCOUNT THE RICHMOND AND THE DEEP RIVER COALS WOULD SEEM TO BE OF THE SAME HORIZON, AND THE FARMVILLE AND DAN RIVER COALS ALSO OF THE SAME; AND ALL TO BELONG TO THE GWYNEDD SHALES. THE NORTHWESTERN AREAS, NEXT THE BLUE RIDGE, SEEM TO BE LATER, AND TO CONTAIN THE PERKASIE SHALES. THE NORRISTOWN SHALES MAY OCCUR IN THE EASTERNMOST AREAS.

West Virginia and southwestern Pennsylvania (Pa. State Geol. Report PP, 1880), as Prof. J. J. Stevenson's researches (Report K, 1876) had already made probable and as Rogers (1858) had suspected to be not unlikely. Lithologically there would seem to be much resemblance between those Permian beds and the Norristown shales, a confirmation, to some extent, of the hitherto scanty indications of our eastern fossils.

It is probable, therefore, that not all of our New Red can be reckoned as Mesozoic, and the age of at least its upper half is from the rarity of reported fossils extremely obscure. The great thickness of the whole series then, is not in the least inconsistent with any known paleontological observation and is consequently no longer a mystery that stands in need of explanation or of disproof, or at least of discredit by means of violent hypotheses.

Nor in the New Red fields of other states is there anything that does not readily harmonize with the results of our two counties. In the Proceedings of the American Philosophical Society, Vol. XXXIII, 1894, pp. 192-215, it is shown with three maps, here reproduced (Massachusetts and Connecticut on one map, Pl. 596, New York and New Jersey on another, Pl. 597, and Virginia and North Carolina on the third, Pl. 598), how our five subdivisions of the whole series may be traced with some probability in the other states by means of observations previously published, particularly by Hitchcock, Percival, Cook and F. L. Nason in the Massachusetts, Connecticut and New Jersey State Geological Reports, and by Prof. Davis, I. C. Russell, N. H. Darton, W. B. Rogers, O. J. Heinrich and Prof. W. M. Fontaine in their well known very valuable memoirs. And especially help is received from the New Jersey and United States Geological Surveys' topographical maps, throughout New Jersey and Connecticut and Massachusetts, as well as, in Virginia and North Carolina, from O. J. Heinrich's map (copied, Maj. Jed. Hotchkiss says, from Wm. B. Rogers' map published by Hotchkiss in 1876). It is pointed out (p. 215) "that although the New Red beds do not everywhere exist in the same completeness as in Montgomery county, yet certain portions are pretty fully represented in distant states, the lower third in Connecticut, the lower half in northeastern New Jersey, and the lower portions and upper portions in separate basins in Virginia."

In addition to the facts given here and on the map and cross-sections in ample demonstration, as it seems, of the thickness of the whole series of beds and of the five sub-divisions, still much fuller details of the character of the observed beds have been set forth in the couple of thousand columnar sections of exposures already spoken of as drawn to one uniform scale. In connection with them, fifty township contour-line maps on a uniform scale, covering the whole field, have been drawn, for the purpose of displaying separately the geology of each township with every observed exposure to be marked on the map and with every section to be described in full in the text of a special report on each township. Several such reports were written. But it has seemed on the whole unnecessary at present to undertake so much additional expense as the completion and publication of all that work would require; especially as the survey has already cost (not to the State, but privately) several times as much time and labor as any one dreamed of at the outset. The demonstration of the principal facts seems to be quite full enough as it is.

Trap.

Deposits.—Rogers' report and map of 1858 indicated several occurrences of trap-rock, two of them quite large, within the limits of the New Red of our two counties. Further investigation has shown that the occurrences are still more numerous and on the whole much more extensive. It seems, to be sure, to have been formerly supposed that the extent of solid trap in place beneath the surface of the ground was equal everywhere to the space covered on the surface by scattered trap blocks and decomposed trap earth. But it appears from the comparatively narrow limits of the solid trap where streams have cut across it and carried away the superficial loose material, so as to leave the sedimentary shales exposed, that the solid trap deposits are generally much less wide than the superficial outspread of broken and decomposed trap material or rubbish. As the greater hardness of the trap has enabled it to resist erosion more successfully than the shales could do, it tends to stand out in the form of hills above the shales. It is safe, then, to take the shape of the hills as to some extent a very useful guide to an estimate of the breadth of the underlying solid trap; and to consider that at the side of it more or less ground may be covered by trap rubbish that has either been spread there through rolling or sliding down from the adjacent trap ridges or through getting washed there by the eroding waters, or through being simply left lying there after the erosion of once overlying beds of solid trap. It is perhaps rather to be wondered at that there is not even a greater quantity of such scattered rubbish remaining over a still wider extent of country, considering the great hardness of the trap. We should, however, consider, not merely its hardness when fresh, but its liability to decompose and soften in geological ages, owing to the comparative instability of some of its constituent minerals. This feature of the trap is shown very well in the exposure of the dike on the Trenton Cut-off Railroad presently to be described and illustrated with Plate 599. The dike, although 25 yards across makes very little show on the surface of the ground; and it is seen that about two-thirds of the breadth of the dike is completely decomposed down to the level of the railroad, and the whole to the depth of a dozen feet or more from the surface. Plainly some parts have decomposed more readily and thoroughly than others, so that only here and there along the outcrop of the dike undecomposed blocks occur on the ground. Evidently the traps of our field are much more readily decomposable, and for that reason make much less show at the outcrop, than the very conspicuous dike of Cumberland and Perry Counties, crossing the Blue Mountain and forming a ridge fifty feet high.

As for solid trap in place, there are extremely few points, perhaps hardly half a dozen, in the two counties where it is to be actually seen. Everywhere else it is merely the trap rubbish, either bowlders, in many places so numerous as to cover the whole ground, and sometimes as large as small houses, or still more universally the peculiar yellowish gray loam of fully decomposed trap, always accompanied by larger or smaller blocks. On the printed map the spaces supposed to be underlain by solid trap are indicated with a full color, and those that are merely more or less covered by trap rubbish are given with scattered dots of the same color. In some cases there appear to be two or three distinct deposits of trap, where the surface of the ground is covered by one single outspread of the trap rubbish; and it is quite possible that in many other places there are interbedded shales now completely covered by the broad blanket of decomposed trap.

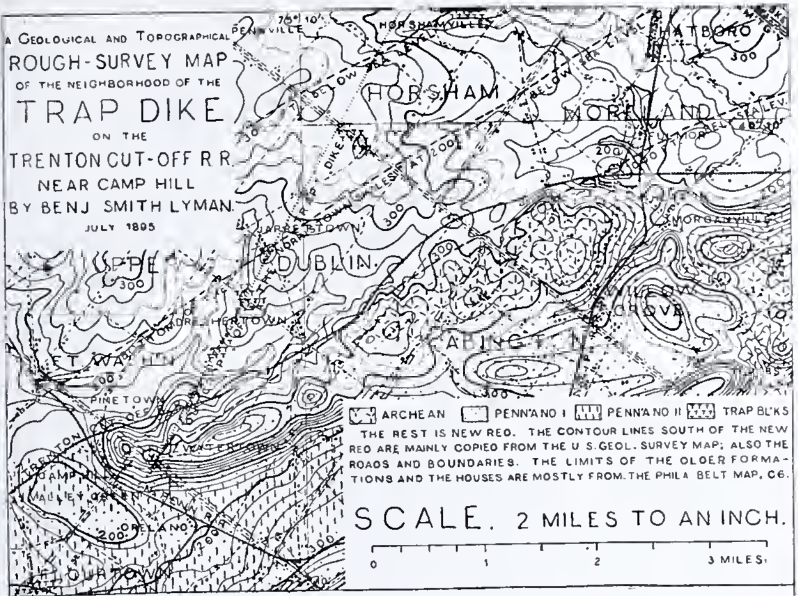
It is seen on the map that the largest trap deposit is at Haycock Mountain and thence growing narrower southwestward to Sumneytown, with a decided bend northwestward at the boundary between the two counties; following everywhere one geological horizon near the top of the Perkasie Shales. Eastward of Haycock Mountain on about the same horizon a smaller deposit is seen in Nockamixon Township, near the Delaware, in a horse-shoe shape, conformable to the shales; and a couple of small trap hills are seen still on nearly the same horizon between that and the Haycock trap. In the centre of the horse-shoe shaped trap there is apparently a small trap hill on a higher geological horizon in the lower part of the Pottstown Shales. But the whole country hereabouts is covered with trap rubbish, and goes by the name of "the Swamp." The country west of the Haycock is also extensively covered with trap rubbish that is perhaps partly supplied by some underlying hidden masses of solid trap of the horizon just referred to, besides the main trap of the mountain. Near Sumneytown a long trap deposit begins at a little higher horizon in the lower part of the Pottstown Shales, and with a very crooked course conformably to the shales extends past Perkiomenville, Zieglersville and north of Shwenksville nearly to Sanatoga. Three other masses of somewhat higher horizons continue the hill westward to the county line, north of Pottstown; three separate masses apparently, though the whole space above and between them is covered with trap rubbish. The three seem to correspond with other masses at the same horizons on the north side of the Boyertown basin; and again north of the next basin, north of East Greenville; and the two upper ones yet once more north of Quakertown and near Coopersburg, Lehigh County. Two or three other horizons in the Pottstown Shales have very small trap masses near the northwestern edge of the field.

South of the Paleozoic "island," the Norristown shales have a small trap mass just across the Delaware north of New Hope and Lambertville. A mile and a half southwest of that trap and within the limits of the Paleozoic limestone of Solebury Township there are two small trap dikes visible in place, at W. L. Ely's (formerly D. Ely's) quarry. One is about three feet wide and has a dip of 55 degrees south 75 degrees east; and the other is about 7 feet wide and runs north 10 degrees west with a steeper dip. No trap has been found in the Lansdale Shales northwest of the Paleozoic "island;" but south of it there is a somewhat important mass at Solebury Mountain near their top, and another at Jericho Mountain and Bowman's Hill, about their middle, and apparently in striking conformity to the very much twisted condition of the shales.

In the lower part of the Gwynedd Shales, just below Pt. Pleasant, on the Delaware, there is a trap mass of comparatively small thickness that seems to conform to the shales and to extend a mile southwestward from the river, and to be bordered by trap rubbish two miles further. Indeed, with some gaps the trap blocks and rubbish, in great part very scantily, extend nearly nine miles from the river along the outcrop of the same horizon; and then after another short gap are continued by trap rubbish, across the strike of the shales, two or three miles further to the great fault near Chalfont. South of the fault there seems to be no continuation of this trap or trap rubbish; but four miles eastward and more than two miles south of the fault, and directly south of Doylestown, begins a space sparsely covered with trap rubbish that extends south, across the strike of the shales, five miles to Horshamville. Thence southwestward past Dreshertown to the edge of the field there are four very small patches of trap rubbish; and by an oversight a couple of others were omitted from the map, all nearly in the same straight line.

An exposure of a trap dike near by has also been observed on the new Trenton Cut-off Railroad since the map was printed. The dike is 25 yards wide, runs north about 30 degrees east, and dips 75 degrees northwesterly. The accompanying Plate 599 shows all the known occurrences of trap in that neighborhood, as well as a correction of the southern limit of the New Red. The precise limit is the more obscure from the occurrence of much red quartz in the neighboring Paleozoic rocks, and from the gray color of some adjacent shaly sand rock of the Norristown Shales. The trap exposure comes just in the line suggested by Mr. C. E. Hall (Report C 6, pp. 20 and 23) as the probable place of a dike connecting several of the occurrences of trap blocks, from near Oreland to the large one near Horshamville, and turning off at an angle of 32 degrees from the Conshohocken dike at Flourtown. There is no evidence, however, that the dike of the Cut-off extends all the way to Flourtown. It is furthermore noticeable that trap blocks occur a mile southeast of Morganville, as mentioned also by Mr. Hall,

PLATE 599

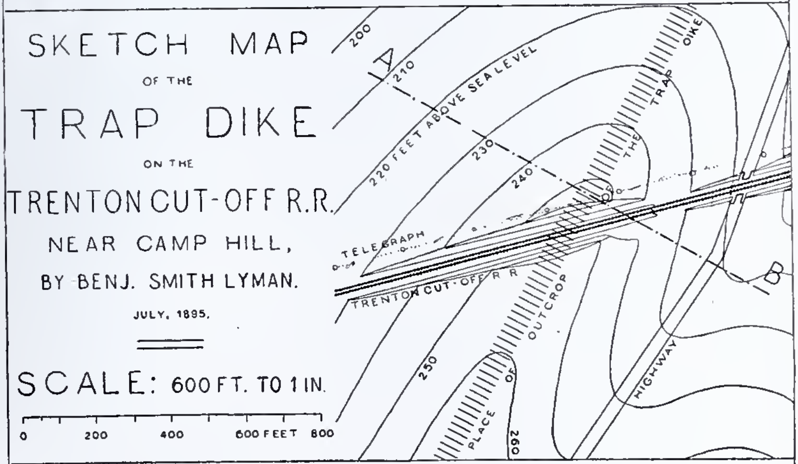


A GEOLOGICAL AND TOPOGRAPHICAL ROUGH-SURVEY MAP OF THE NEIGHBORHOOD OF THE TRAP DIKE ON THE TRENTON CUT-OFF R.R. NEAR CAMP HILL BY BENJ. SMITH LYMAN. JULY 1895

ARCHEAN ☐ PENN'A NO I ▥ PENN'A NO II ▨ TRAP BL'KS

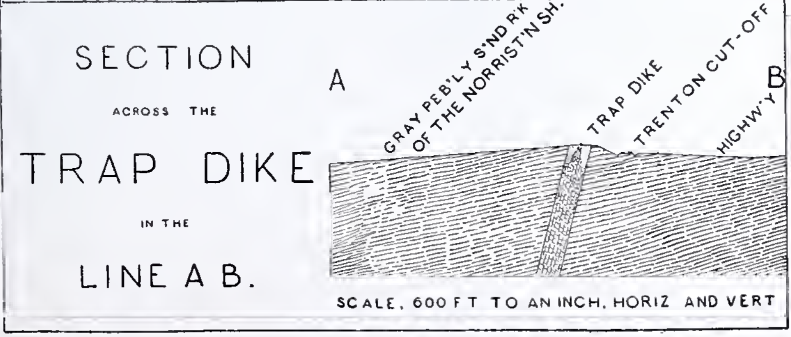
THE REST IS NEW RED. THE CONTOUR LINES SOUTH OF THE NEW RED ARE MAINLY COPIED FROM THE U. S. GEOL. SURVEY MAP; ALSO THE ROADS AND BOUNDARIES. THE LIMITS OF THE OLDER FORMATIONS AND THE HOUSES ARE MOSTLY FROM THE PHILA BELT MAP, C6.

SCALE. 2 MILES TO AN INCH.



SKETCH MAP OF THE TRAP DIKE ON THE TRENTON CUT-OFF R.R. NEAR CAMP HILL, BY BENJ. SMITH LYMAN. JULY, 1895.

SCALE: 600 FT. TO 1 IN.



SECTION ACROSS THE TRAP DIKE IN THE LINE A B.

SCALE, 600 F T TO AN INCH, HORIZ AND VERT

exactly on a prolongation of the line of the Conshohocken-Flourtown dike.

It is evident that almost all the solid, undisturbed trap in the whole northwestern half of the field and in the part just south of the Paleozoic "island" occurs in the form of sheets or beds conformable to the sedimentary rocks. It was formerly supposed by Rogers and others that such sheets, as well as all other solid trap, were dikes, and that they had forced their way intrusively between the beds, in some cases to immense distances, without essential departure from a single bedding plane, even in comparatively soft shales. Hitchcock long ago showed that such a conformable sheet of trap was not always intrusive, but an overflow contemporaneous with the sedimentary beds; that is, that it had flowed over the still level surface of the underlying sedimentary beds before the deposition of the overlying ones. Prof. Davis has done yeoman's service in proving that it is so with many trap-sheets that were formerly called intrusive; and his demonstrations in regard to the trap-sheets of the Connecticut Valley and New Jersey have been very useful in our two counties, where opportunities of observing the trap in place are so exceedingly rare. Even he, however, was perhaps not always exacting enough in requiring proof of the intrusive character of the trap; since he admitted that the great trap-sheet of the Hudson River Palisades was intrusive, for reasons apparently not completely cogent. The out-crop of that sheet is over fifty miles long and extremely crooked, but as our little map shows, evidently conformable in the most striking manner to the geological structure of the sedimentary rocks through the whole northern part of the New Jersey Red field. It would need thoroughly invincible arguments, strong beyond a shadow of doubt, to persuade one that such a sheet was not an overflow.

In our two counties, at all events, there would seem to be no good reason whatever for considering the conformable trap-sheets anything but overflows, and any other supposition would now seem very strained. We may safely reckon, then, as overflow sheets almost all the traps of the northwestern half of the field, that is the trap of Haycock Mountain, and those of about the same horizon eastward to the Delaware, and those a little later southwestward towards Pottstown and northwestward to the county lines; and also, southward, the small deposit near Point Pleasant, and the larger ones of Solebury Mountain and of Jericho Mountain and Bowman's Hill. Nevertheless, in all these numerous and widespaces the only place where the contact of the trap with the overlying or underlying shales could be seen, so as to confirm the overflow character by a direct observation of that kind, was in the railroad cut a mile and a half south of Quakertown; and there the shales below a very uniform twenty-foot bed of trap seem to have been baked, but the ones above to have been unaffected.

Several other deposits, however, are clearly dikes, as shown by their cutting across the strike of the sedimentary beds in the way already noted. An observation of trap in place, on the west bank of the Perkiomen Creek at Perkiomenville seemed at first sight to make the trap appear conformable to the adjacent shales with a nearly vertical southwesterly dip; but it was doubtless only a conformity of cleavage planes of both the trap and shales, though the shales have bands of somewhat different colors parallel to those planes. The trap here would seem to be the dike itself that supplied or helped to supply the great bedded trap mass that it adjoins. For the igneous rock of the overflow sheets probably came generally to the surface through long dikes rather than through circular volcanic craters. It is noticeable that the dike is in the very axis of an important anticlinical. There would also seem to be a dike of trap crossing the shale beds in the northwestern corner of Bucks County, forming hills between Spinnerstown and Geryville, in Milford Township; and that dike also apparently supplied the widespread trap bed that occurs just to the northwest. The dike descends the flank of a sinking anticlinical, and is near its axis. The actual sources or original dikes of the northern trap beds have not been observed elsewhere. At several places in the southern part of our field (besides Ely's quarry and the Trenton Cut-off already mentioned), dikes appear to exist; although no overflow sheet is now connected with them, because their overflows, as well as the sedimentary beds that formerly underlay them, have been completely eroded away. All the patches of trap rubbish that have been mentioned southward from Point Pleasant were regarded by the late Prof. H. Carvill Lewis as evidence of a great trap dike running through that part of the country, broken by the great fault with a heave of four or five miles (Am. Phil. Soc. Proc. Vol. XXII, 1885). On closer examination, it would seem, rather, that the patches of rubbish that cross the strike are evidence of the existence of a number of smaller discontinuous dikes.

Age.—It appears then that most of the trap occurs in the form of overflow sheets laid down during the deposition of the Pottstown Shales, and especially one large mass, that of Haycock Mountain, slightly earlier near the top of the Perkasie Shales. During the time of forming the Lansdale Shales, trap flowed upon them, in these counties, only near the Delaware, at Solebury and Jericho Mountains, and not very extensively there. The only earlier contemporaneous deposit of trap was the small one in the Gwynedd Shales near Point Pleasant. In New Jersey, however, a very large trap overflow seems to have occurred near the beginning of the Norristown Shales; and in the Connecticut Valley, the time of igneous activity was apparently likewise during the period of the Norristown Shales, and almost solely then, though not at their very beginning. The occasion of the great outflows of igneous rock would therefore seem not to be the pressure downwards of the great load of New Red rocks, with the fissures thereby opened, as it might possibly have been inferred to be if only our two counties were regarded.

Lithology.—Prof. Amos P. Brown, Ph. D., has, at my desire, very kindly contributed the following brief account of the lithology of the trap of the two counties, a subject he has lately been investigating with great ability:

"Notwithstanding their wide distribution and apparent differences in age the trap rocks of the Mesozoic area in Bucks and Montgomery Counties are remarkably similar in structure and lithological composition. Quite as marked variations may often be detected in these rocks from one continuous deposit as would be found by comparing those from isolated occurrences in this area. But four species of rocks are represented and these have nearly the same minute structure and are genetically connected. They are all plagioclastic rocks, and contain in addition to the plagioclase either a pyroxene or a hornblende, and generally titanic magnetite. The four species distinguished are diabase, dolerite, gabbro and epidiorite. The structure in all approximates what is called ophitic, the rock consisting of more or less distinct lath-shaped plagioclase cystals mixed with granular or less perfectly crystallized pyroxene or hornblende and granular titanic iron. The diabase and dolerite may be considered the original rocks, the gabbro and epidiorite being derived from them by metamorphic action. Without entering into the question of the intrusive or extrusive character of these rocks it may be stated that the basal portions of the deposits show the greatest alteration in each case.

"Diabase.—The rock consists of a granular or crystalline base of augite containing embedded lath-shaped cystals of plagioclase and with very little titanic iron. The relative amounts of plagioclase and augite vary much in these rocks, but those with more augite generally show less alteration than the others. There is excellent evidence that this is the original rock from which most of the gabbro was derived. A typical occurrence of this diabase is at the "Ringing Rocks" at Upper Black's Eddy, Bucks County.

"Dolerite.—This rock resembles the diabase in composition, but contains much titanic iron in addition to the plagioclase and augite, and often, too, contains olivine. Such rocks as those in the Conshohocken dike are of this character, or that in the deposit south of Point Pleasant on the Delaware. In this dolerite where the magnetite is present in considerable amount it is often associated with sphene.

"Gabbro.—By far the greater part of these traps are gabbro, and have resulted from the alteration of the diabase in most cases, less frequently from alteration of the dolerite. Gabbro consists of diallage and more or less saussuritized plagioclase. The diallage is a pyroxene with a strong orthopinacoidal parting, and is derived from the original augite. In addition to these two constituents, titanic iron and sphene may also be present. These gabbro vary much in color according to the proportion of diallage present or the size of the grain, the finer grained rocks being dark grey to nearly black, while the coarse rocks may be light grey. All stages of alteration from the original diabase or dolerite to this gabbro may be traced in these rocks, and they also grade insensibly into the final stage in the alteration, the epidiorite. This gabbro is typically developed at Rockhill Station, and also at Shelly Station on the N. P. R. R., near both of which places it is worked for paving block, but quite as characteristic occurrences are to be seen on Solebury Mountain, or the Haycock or in the "Swamp."

"Epidiorite.—This consists of saussuritized plagioclase, hornblende, paramorphs after augite and magnetite. The saussnrite is generally the augite-zoisite, mixture. In the change of the augite into diallage, and finally into hornblende, much magnetite is set free in small octahedral cystals. The titanic iron when present alters usually in great part into sphene.

"This rock, on account of the presence of the hornblende is generally of a greenish color and is more tough and difficult to break than the gabbro. It can hardly be worked into square blocks like the gabbro. A very typical occurrence of it is at Jericho Mountain which consists largely of epidiorite, and the basal portion of the traps near Coopersburg and New Hope are this same rock.

"Chemical analyses of many of these rocks are given in Survey Report C 6, to which reference may be made."

ECONOMIC GEOLOGY.

The economic geology of the two counties is much less important than it is in some parts of the State; yet the field is not wholly lacking in very useful minerals, nor, on the other hand, in enticements to waste much money in fruitless mining if the subject be not well investigated.

SOIL.

The prevalent red beds of the Pottstown Shales, the Lansdale Shales and the Norristown Shales, are generally somewhat calcareous, and form in decomposing at the outcrop a very fertile soil. Accordingly the colors that indicate those shales on the map show also where the land is mainly good for farming. Of course, something depends, too, upon the configuration of the surface of the ground, as shown by the contour lines, whether comparatively level or rough with hills. In some places the surface is too flat to be readily drained, and occasions swamps; and in some regions the fertile shales are too thickly strewn with trap bowlders to be readily tilled.

The land underlain by the Perkasie Shales is generally less fertile than that of the neighboring red shales, above and below. But the dark Gwynedd Shales have the least fertile land of all, with a cold soil, except perhaps in the upper part, where the color, too, is less uniformly dark. Nevertheless, patience and skill have accomplished good results upon them in Plumstead Township and elsewhere.

The trap when fully decomposed to earth is not infertile, as is to be seen in Nockamixon and Haycock Townships and elsewhere; but commonly the trap earth is too much encumbered with trap bowlders to be easily cultivated, and it is most often left to be covered by forests.

Building Stone.

The most valuable mineral deposits beneath the soil of the counties are the building stone.

The brown sandstone much used for buildings in Philadelphia and elsewhere comes from a couple of thirty-foot beds at about 150 feet and 350 feet below the top of the Norristown Shales. The quarries are at Yardleyville (Kirkman's, Nickleson's, Anderson's) at Newtown (Mitchell's), at Grenoble Station on the Northeast Penn. R. R., and near it; and near the Perkiomen Stone Co.'s quarry, above Valley Forge, on the Schuylkill, though not so celebrated here for its ornamental quality. The same beds, too, appear to be partly exposed back of Lumberville and near Gardenville, and north of the Little Neshaminy near Jacksonville. No doubt they could be opened at many other points where favorable to railroad or river or canal carriage and to easy stripping of the surface covering. Yet the quality near the Schuylkill is likely to prove not equal for fine building work to what it is at Newtown and Yardleyville. The probable place of outcrop of both beds of building stone is marked throughout on the map by dotted lines; so that the beds can easily be tested wherever the stripping conditions indicated by the contour lines and by the dip are favorable.

The next lower, gray, somewhat pebbly sandstone in the Norristown Shales are strong and, though less easily worked, are serviceable for bridge piers, cellar walls and foundations generally. On the canal below Yardleyville, and on the Neshaminy below Newtown, they were formerly quarried; and they are extensively quarried above Norristown along the railroads on both sides of the Schuylkill; and they are also quarried near Lumberton. The outcrop of these beds can also be found without great difficulty by their distance from the two beds of brownstone already mentioned.

The yet lower, more pebbly sandstones have likewise been a good deal quarried below Yardleyville for foundation walls; and still are so to some extent.

The trap is a very strong, durable building stone; but is rather hard to work, and is of sombre color. Of course, it would be excellent for foundations or for bridgepiers.

Paving Stones.

Paving-stones of excellent quality are made from the trap at several points, chiefly from the trap bowlders. The principal quarries of that kind are near Rockhill and Shelly Stations, on the Bethlehem line of railroad, and at Spring Mount on the Perkiomen Railroad, and near Perkiomenville. The trap is very well suited for the purpose; and evidently it could so be utilized at many other points where railroad or canal carriage is favorable.

The gray sandstone about 1,000 feet below the top of the Norristown Shales is quarried for paving stones at Lumberton in Kimball's quarries.

Road-Metal.

Road-metal of excellent durable quality for macadamizing is made from trap; and to some extent the trap has been so utilized in different parts of the field. But road-metal is usually obtained from small road-side quarries in the harder layers of the shales, wherever they occur; and thereby the material is not carried to any great distance.

Coal.

Hopes of finding valuable coal have been raised at several points by beds of a very few inches of it and by blackish shales; and a good deal of money has at times been wasted by the over-sanguine, and might still continue to be thrown away were the results of a thorough geological survey of the whole field not entirely against any such outlay. It is true that near Richmond, Va., and in North Carolina, workable beds of coal occur in rocks apparently of the same age as our Gwynedd Shales; but in these two counties there can be no reasonable hope of finding any workable bed of coal. Such a bed with its outcrops necessarily many miles in length, if nowhere completely exposed, would at least have occasioned many striking indications that would be sure to have been discovered long ago by the very observant inhabitants of the country; and they have, indeed, made expensive trial of several thin coal layers and of black-shale-beds that any geologist would have known to be valueless.

At Dark Hollow, near the ~~Little~~ Neshaminy, in Warwick Township, a few inches of coal were found in the dark Gwynedd Shales, and were drifted upon many years ago for a number of yards; but it was found not to exceed perhaps two or three inches in thickness, and was of course wholly unworkable. On the North Branch of the Neshaminy in New Britain Township, coal was said in the newspapers to have been found in August, 1893; evidently in the same Gwynedd Shales, and no doubt equally delusive.

Prof. Oscar C. S. Carter has called attention (Franklin Institute Journal, Aug., 1894), to another point in the Gwynedd Shales, on the Shirley Farm, at Arcola Station, on Perkiomen Creek (near the mouth of Skippack Creek, where the newspapers had asserted that a vein of anthracite coal 26 inches thick had been opened. On visiting the place, however, he found the pit inaccessible, but the coal was said to vary from 26 inches to one inch in thickness. Some coal that seemed to have been thrown out from the hole proved on his assaying it to be anthracite, partly of excellent quality. The existence of anthracite in these beds, however, at a place so remote from any igneous rocks that might have produced anthracite from bituminous coal, would be so improbable that it needs the strongest possible evidence by a perfectly trustworthy unbiassed observer that he has actually seen it in place before it was dug from the rock-beds. But even a bed of it of that small and variable thickness would be insufficient encouragement to working it.

Prof. Carter also mentions coal three inches thick half a mile west of the Trooper Tavern, in Lower Providence Township, Montgomery County; black coaly shales at Gwynedd; coal in a bored well at North Wales; coaly slate in a bored well on the Duffield farm, between Custer and Belfry stations, on the Stony Creek R. R., Worcester Township; and two inches of coal in the Pennsylvania Railroad tunnel near Phoenixville; all of them plainly in the Gwynedd shales. Again, he speaks of coal found in a deep bored well at Lansdale, evidently in the Lansdale Shales, and an inch of coal at Norristown, clearly in the Norristown Shales, a couple of thousand feet below the top. At about the same horizon, a still thinner carbonaceous layer, or even coal, of scanty extent, perhaps remains of a single tree, was observed in a quarry near Yardleyville on the Delaware.

Several layers of the Perkasie Shales are quite blackish and have occasioned some unrewarded outlay in the search for coal. Such layers have been particularly noticed by the roadside near Rufe's Corner and at the Revere boring (see Am. Phil. Soc. Proc. Vol. XXIX, 1891), both in Nockamixon Township; also on the McDevitt farm, near Ottsville; and near Perkasie, Blooming Glen, Harleysville and Sanatoga. There is, of course, no reason whatever to suppose that any useful coal bed hitherto undiscovered can exist among the shales, exposed as they are through about sixty miles of outcrop between the Delaware and the Schuylkill in a region so thickly and so intelligently inhabited.

OIL.

The Revere well was bored in 1890 and 1891 over 2,000 feet deep in hopes of finding oil, but without any success. There is no reason whatever to expect rock-oil to be found anywhere in the two counties.

Lead, Zinc and Copper.

Doan's mine, at New Galena, on the North Branch of the Neshaminy, in New Britain Township, three miles and a half northwest of Doylestown, was opened about 1863, was worked a little as late as 1888, and according to a newspaper account was about to be reopened in 1891, to be worked six months under an option to purchase in case the vein of ore should be found to be twelve inches wide. When visited in 1889, the mine was a hole some fifty yards long by twenty yards wide, full of water and quite inaccessible. It is said to be fifty feet deep. The dump showed very little galena indeed, much quartz, specks of copper pyrites, traces of malachite and a little zinc blende. The country rock appears to be blackish gray hard shales. It is not at all probable that any workable vein exists here. The mine is geologically about 800 feet above the bottom of the Gwynedd Shales.

The Perkiomen Lead and Copper Mines, and the Ecton Mines, near together, a mile east of Oaks Station and a half mile northwest of Shannonville, in Lower Providence Township, are said to have been opened about 1850 and abandoned before 1870, and are now quite inaccessible. The old dumps have still some specimens of ore: at the Perkiomen Mines, chiefly quartz, a little copper pyrites and traces of malachite, with light reddish gray coarse sand-rock as the country rock, and without any galena or blende observed by us; and at the Ecton Mines, quartz, blende and galena, with only traces of copper pyrites, and with country rock perhaps like that of the Perkiomen Mines, but possibly dark red, coarse, rather sandy micaceous shale. The mines at both places are geologically about 400 feet above the bottom of the Gwynedd Shales. It cannot be doubted that they were judiciously abandoned, as lacking any veins that could be worked with profit.

Several similar mines, on about the same geological horizon, four or five miles further west, in Chester

County, nearly a mile south of Phoenixville, were likewise abandoned some years ago, after a trial of many years.

Several beds among the Perkasie Shales contain traces of copper in the form of minute scales of bright green malachite. And on Abraham Charles's farm, half a mile south of Sumneytown, some trial shafts were sunk, mainly in 1889, but beginning about 1885, to test some still stronger evidences of copper ore. Apparently, however, only very insufficient traces of copper pyrites and malachite were found in a nearly vertical vein about seven inches wide, especially in the southern three inches. The vein is in dark reddish gray calcareous very hard shale, about 800 feet geologically below the top of the Perkasie Shales.

At about the same geological horizon and about a mile southeast of Sumneytown, on Abraham Kober's farm, three trial shafts were likewise sunk about 1879 to test some signs of copper ore; but without good success. The deeper holes, 50, 40 and 24 feet deep, were full of water and inaccessible when visited in 1889; but among the material that had been thrown out, there was a little malachite, copper pyrites and azurite, and some calcite. The vein was said to be two feet wide and to run east and west. A hole nine feet deep dug in 1889, showed traces of malachite.

Evidently all these places are so very unpromising that it would be a highly imprudent outlay of money to undertake any further trial shafting.

In Nockamixon Township, near Upper Tinicum Church, on Mr. Jacob Tettemer's farm, about a mile northwest of Uhlerstown, a trial digging 20 or 30 feet deep was made by Mr. Culmer, of Easton, about 1876; but it was quite fallen in when visited in 1889. Only traces of malachite were found; and no hopes were, or ought to be, built upon the result. The spot is geologically about 100 feet above the bottom of the Perkasie Shales.

All the ore veins, except those of the Perkiomen, Ecton and Phoenixville Mines seem to be too far removed from the subjacent Paleozoic or Archean rock to be likely to have derived their ore from them instead of from the neighboring shales. The mines just mentioned and the New Galena Mine are so nearly on the same horizon as to make it seem not improbable that these veins also derived their ore from the adjacent shales.

Gold.

Traces of gold are said to have been found in the very pebbly rock at the southern edge of the field on Mr. Henry Haviland's farm, near Lizette Station, and a mile south of Yardleyville; but no thoroughly trustworthy tests of the matter appear to have been made. At the same time, it may be said that the occurrence of traces of gold in this conglomerate derived from the adjacent Archean rocks is by no means impossible. It is, however, hardly probable that paying quantities of it, if existing, should not long ago have been discovered and utilized.

Umber.

A deposit of umber or dark ferruginous earth occurs on the south side of Buckingham Mountain, near the road-forks, where the road crosses the gap in the middle of the mountain, between Pineville and Centreville. A hole about three feet in diameter and said to be about 30 feet deep was dug there, but had quite fallen in when visited in 1889. It was first dug about 1850, but was renewed about 1885. The umber is said to have been darker and purer towards the bottom. Traces of it are said to have been found in a line for about a quarter of a mile southward; but none northward. The place appears to be just inside the Paleozoic rocks, here the Chikis Sandrock, and the traces found southward are probably merely superficial ones carried in that direction by the surface waters. The extent of the deposit is not likely to be very great; but cannot be estimated without more digging.

WATER.

Numerous deep wells have been bored with success for water. There is one about 1,000 feet deep at Pennsburg, sunk in the Pottstown Shales; five or more about 250 and 300 feet deep, at Lansdale in the Lansdale Shales; and two (one dry) at North Wales, in the upper edge of the Gwynedd Shales; and several in the Norristown Shales at Bridgeport, at Norristown, at Jeffersonville, Norriton Township; at Mogee's and Hickorytown, Plymouth Township; at Washington Square, Belfry Station and Sandy Hill, Whitpain Township, and probably elsewhere in Montgomery County; one at Doylestown, said to be 750 feet deep, and several at Newtown and probably other points in Bucks County; and no doubt at many other places in the field. The three sets of red shales would seem to give better results for such wells than the Perkasie Shales or the Gwynedd Shales. What is needed, of course, is a mass of porous beds overlain by comparatively close-grained ones. If the neighboring portions of the outcrop of the porous beds are at a high level, the water will rise in the well to a corresponding height. But apparently none of the wells flow with water at the surface without pumping. Prof. O. S. C. Carter has given details in regard to some of the wells near Norristown in the Franklin Institute Journal (Jan., Sept. and Oct., 1893, and Sept., 1894), and in the Am. Phil. Society's Proceedings (May, 1891).

POTOMAC FORMATION.

On the Neshaminy creek, near the mouth of Mill creek, in the southern edge of Northampton township, there are pale brownish red and light gray nearly level-bedded shales, soft, but apparently too hard to be alluvium, and composed of quartz grains, partly as coarse as large peas, and decomposed light brown feld-spar. It has appeared probable that the beds belong to the lower part of the Potomac Formation, according to its description by Mr. W. J. McGee in the Am. Jour. of Sci., Vol. XXXV, p. 133.

The same formation seems to be visible, again, at Sunny Hill school house, two miles to the northeast, on the Newtown and Langhorne road, near the mouth of Core Creek, in Middletown Township, where there is an exposure of dark reddish gray, light brownish gray and light gray and brown coarse friable almost crumbling, sandrock; in the upper five feet, somewhat shaly with scattered pebbles of glassy quartz up to egg size, and through the lower three feet, soft nearly incoherent sand. The bedding is irregular, with much cross-bedding; and the dip is either level or slightly northerly.

The same formation apparently is seen yet once more at a quarter of a mile further eastward on the north side of Core Creek, in Middletown Township, where there is a roadside exposure of a dozen feet in thickness of mostly light brown and light gray, but in some thin layers dark brown, almost incoherent coarse pebbly sandrock. The bedding is irregular, and the dip seems to be nearly level, perhaps slightly towards the north-northwest.

The whole amount of these beds would seem to be not more than perhaps sixty feet, and they probably occur only at a lower level than the Sunny Hill schoolhouse; that is, for about four miles east from near the mouth of Mill Creek and mostly less than a quarter of a mile in width. No fossils have been found at any of the exposures, and the beds are not of a character favorable to the preservation of fossils.

MAP.

It seems on the whole best to explain certain defects in the printed map, for the benefit possibly of future publications, notwithstanding the risk of calling attention to shortcomings that might have passed unnoticed in some quarters.

As the map in two sheets is rarely united, the very desirable effect of a connected view of the geology and topography of the whole field is generally lost. The map was drawn on the scale of an inch and a half to a mile with the expectation that it would be reduced by photography for printing to a scale of only one half or at most three quarters of an inch to a mile instead of the inch finally adopted; and evidently three-quarters of an inch would have been quite enough to display clearly all the essential facts, and the map could then have been on a single somewhat larger sheet, so as to show the whole field together. But for various reasons the larger scale was finally agreed to, with the expectation that the two sheets would be pasted together.

The manuscript map had upon it the houses scattered through the country, very useful indications, of course, as to the whereabouts of points in the field. But the increased expense made it desirable to consent to the omission of the houses, for the sake of good work in other respects.

The desire was to reduce the lettering on the map to a minimum, so as not to obscure the geology and topography. The names of places were accordingly abbreviated in a way that would be readily intelligible to anybody at all familiar with them, and to others it would be unimportant; but with a key to the names, that would have been sufficiently near at hand, if the whole had been on a single sheet.

The intention was that the surface contour lines should be printed in black, so as to be somewhat more conspicuous, though finer, than the brown lines used; but it was discovered too late that the distant lithographer had by some misunderstanding made them brown, with a separate stone. By a like misunderstanding the intention of having the streams in black, instead of blue, was frustrated, and the system of geological coloring interrupted. With the greatly diminished lettering there would have been no obscurity from having so many lines in black.

It was thought that a separate uncolored edition of all that was to be in black, including the topography and streams and the dips, with the topography re-enforced by shading the hills, would be inexpensive, and would be highly desirable, both for a better idea of the topography unobscured by the geological colors, and for use in any future additional observations in the field. But the increased expense the shading would have required caused it to be abandoned, and by a misunderstanding the lithographer omitted the dips; so that the usefulness of the edition was in a great measure lost. At the same time, the brown color of the contour lines diminished their effectiveness; and the several colors of course tended to make the expense disproportionate to the advantages.

The great distance of the lithographer and the difficulty of printing proofs with so many colors, occasioned some other less serious divergences from what was intended. It would be highly desirable if a satisfactory method of photolithographing manuscript maps could be devised, so that the reproduction of the original work should be exact in all details.

Several assistants co-operated faithfully and zealously in the field work and mapping: Messrs. Amos P. Brown and Jos. Sketchly Elverson, for several months, chiefly in 1889, aided in the field in carefully observing the rock exposures, bed by bed, for the lithological character and thickness of each layer, and in taking specimens and reading the aneroid; and, in the office, helped in the mapping and in labeling the specimens. The last three months of 1889, Messrs. C. H. Kajiwara and F. Koch aided in the field-work and office-work in the same ways and continued in the office the first half of 1890, tracing the mapping and drawing columnar sections. Mr. Kajiwara kept on at such office-work work until September, 1891. In the summer of 1890, Mr. A. DW. Smith assisted in the mapping for a couple of months and in a few days of fieldwork; and later he drew the latitude and longitude lines of the map, and had oversight of the copying of the topography of the sheets of the United States Geological Survey. Mr. Chas. J. Wright aided in such copying, and in tracing it and several township maps; and Mr. Howell T. Fisher aided in the lettering. Much gratitude is due to the State Geologist for the kindly interest shown throughout the work and the complete freedom accorded.

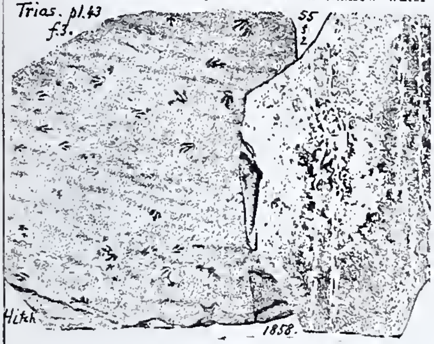
The following twelve plates (Pl. 600-611) were prepared by the State Geologist to illustrate the fossils of the New Red.

BENJ. SMITH LYMAN.

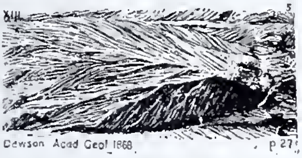
Philadelphia, 8th July, 1895.

Triassic (Mesozoic) ripple marks, &c.

Ripple marks made by the waves in shallow water



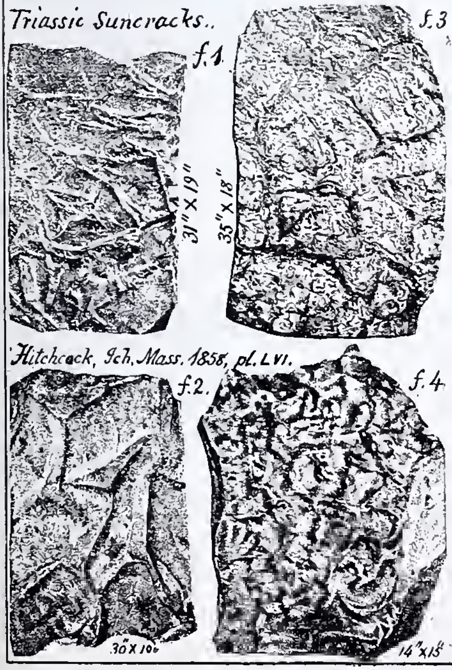
Rill marks



Dawson Acad Geol 1868 p 27

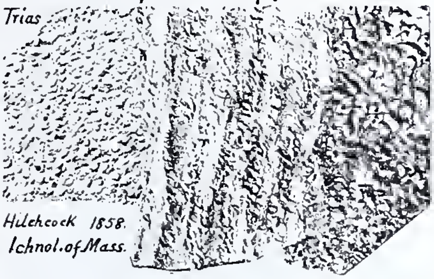
Sun-cracks of various forms fossilized

Triassic Suncracks..



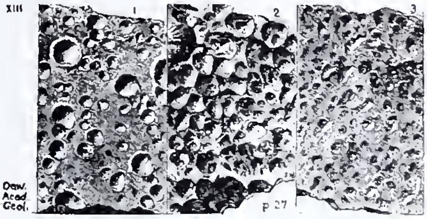
Hitchcock, Ich. Mass. 1858, pl. LVI.

Rain drops on ripple marks.



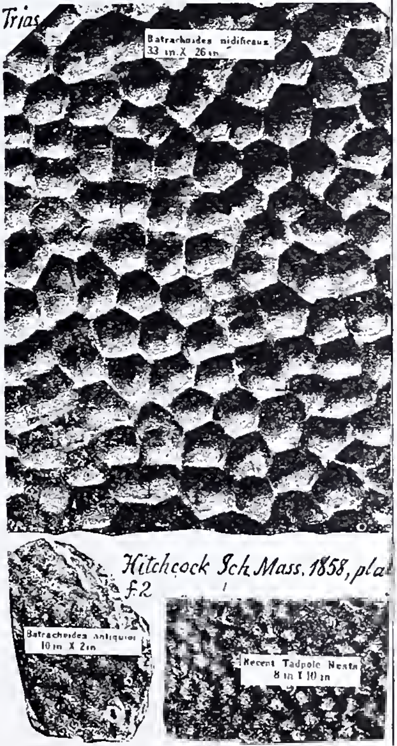
Hitchcock 1858. Ichnol. of Mass.

Rain drops in the Coal age.



Daw. Acad Geol. p 27

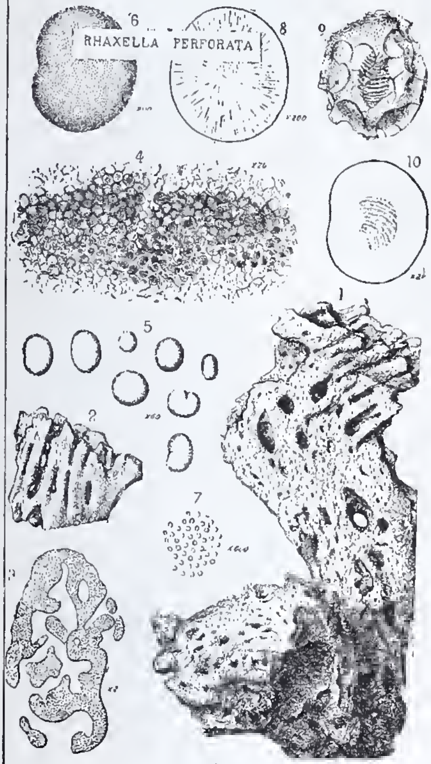
Tadpole nests fossilized.


Trias
Batrachoides nidificans 33 in. X 26 in.
f.2
Batrachoides antiquior 10 in X 2 in
1
Recent Tadpole Nests 8 in X 10 in

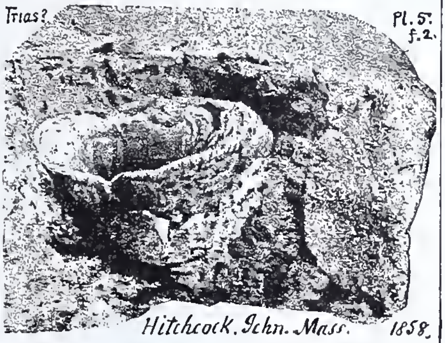
Hitchcock Ich. Mass. 1858, pla

Triassic sponges and (Rhætic) plants

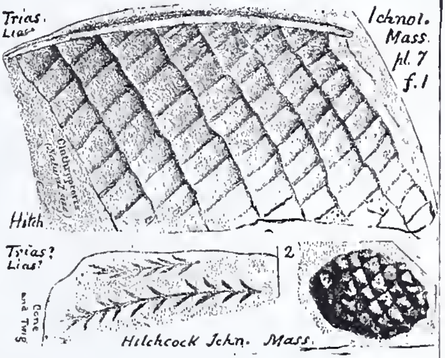
Sponges of Jurassic or Middle Oolite age in England.



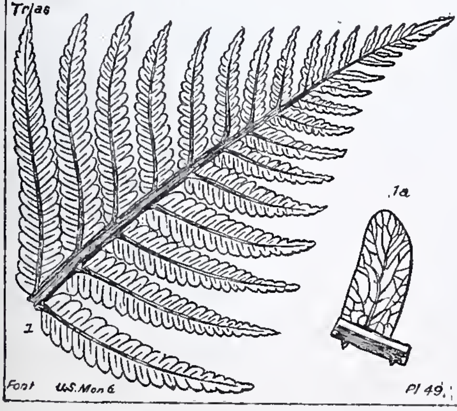
Rudistæ in Connecticut river sandstone. Hitchcock



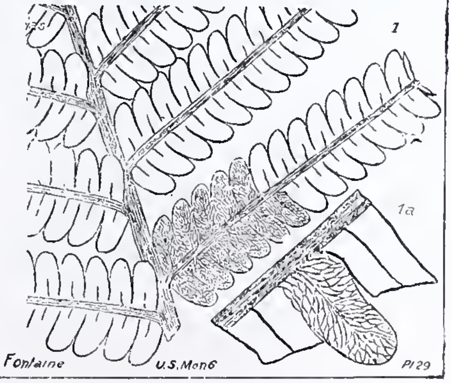
Clathopteris retusculus.



Lonchopteris oblongus, Fontaine. (Acrostichides oblon.



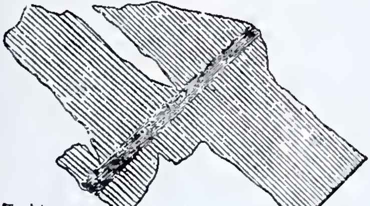
Lonchopteris virginiensis. Font.



Triassic (Rhætic, Mesozoic, Newark) plants.

Macrotæniopteris crassinervis. Feistmantel.

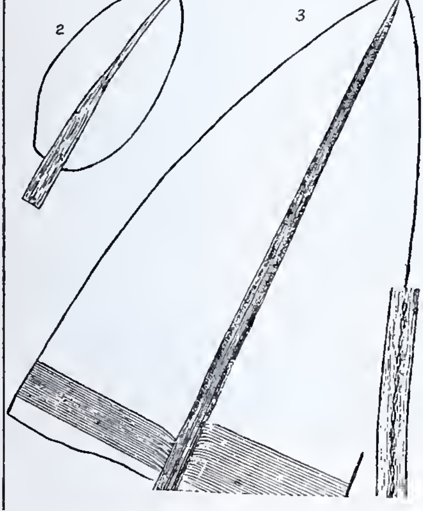
Trias



Fontaine U.S 6 14 6

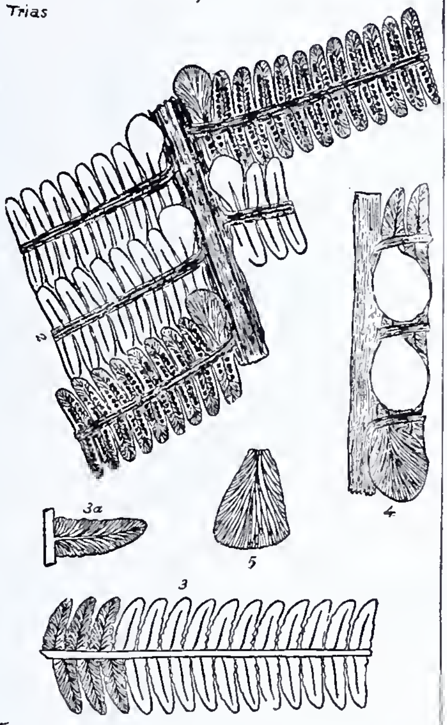
Macrotæniopteris magnifolia (W B. Rogers). Schimper

Trias

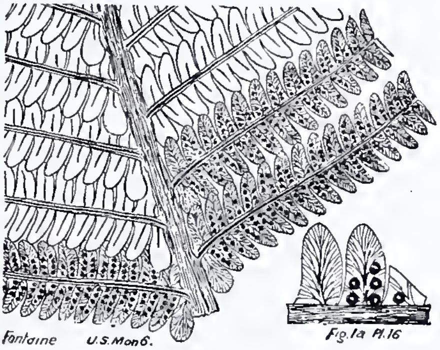


(Mertensides bullatus)

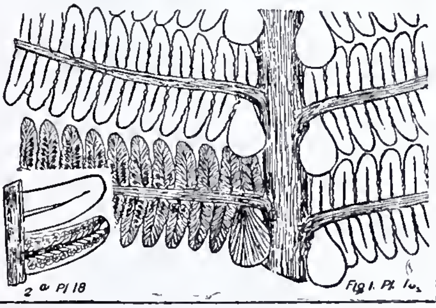
Trias



Fontaine U.S. Mon. 6 Pl. 15



Fontaine U.S. Mon 6. Fig. 1a Pl. 16



2 a Pl 18 Fig 1. Pl. 16

(Merteneides dietans.)

Trias

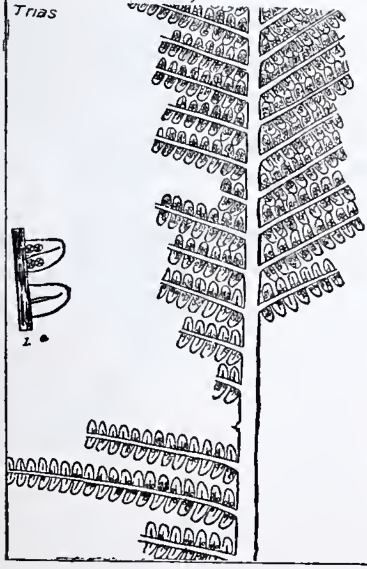
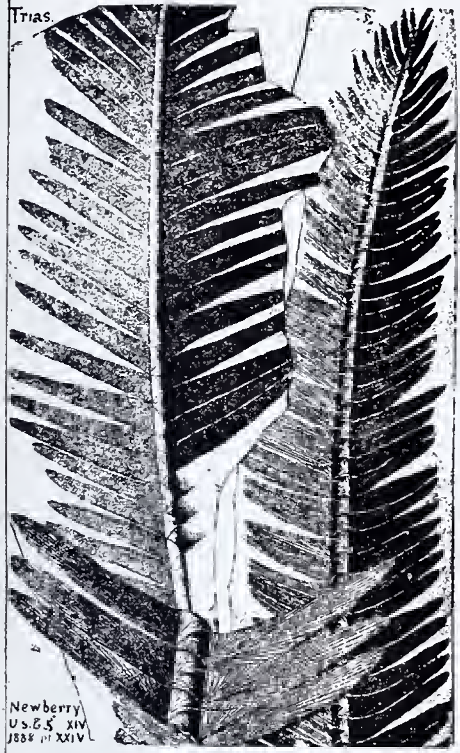


PLATE 603

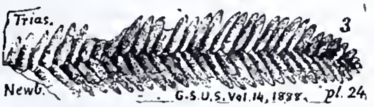
Mesozoic (Triassic, Rhætic) plants.

Otozamites latior.



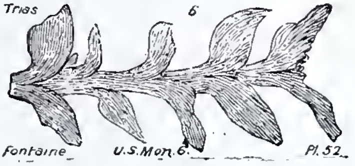
Newberry
U.S.G.S XIV
1888 pl XXIV

Otozamites brevifolius, Fr. Brogniart, Newberry



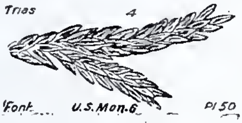
Newb. G.S.U.S. Vol. 14, 1888, pl. 24

Otozamites caroliniensis, (*Albertia latifolia,*



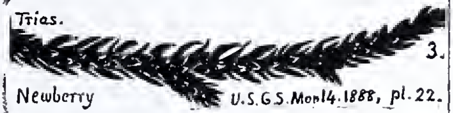
Fontaine U.S. Mon. 6. Pl. 52

Pachyphyllum peregrinum,



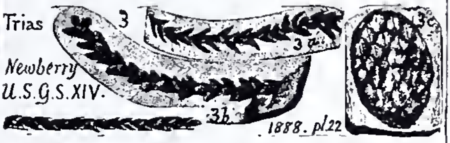
Font. U.S. Mon. 6 Pl 50

Pachyphyllum simile, Newberry



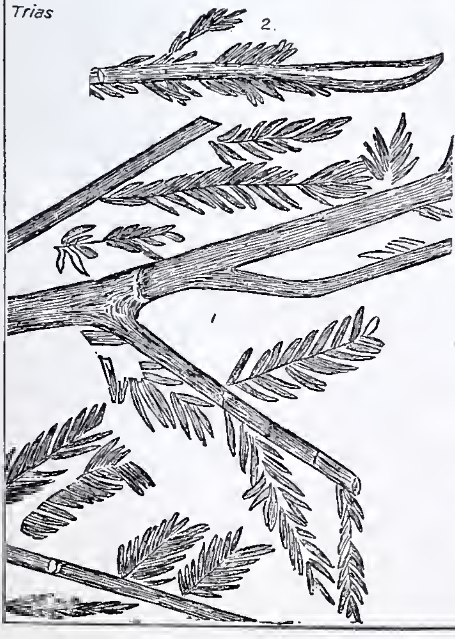
Newberry U.S.G.S. Mon 14. 1888, pl. 22.

Pachyphyllum brevifolium, Newberry



Newberry
U.S.G.S. XIV.
1888. pl 22

(Palissya braunii.



Palissya ? Trunk of a conifer, decorticated

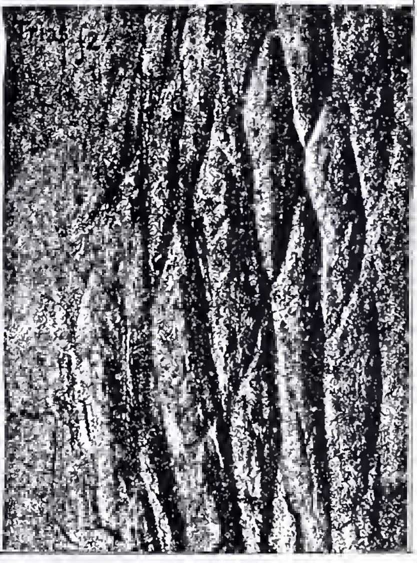
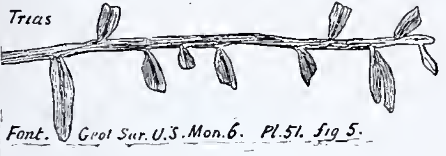


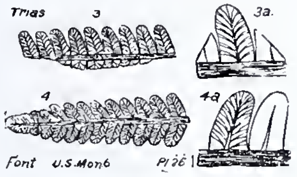
PLATE 604

Mesozoic (Triassic, Rhætic) plants.

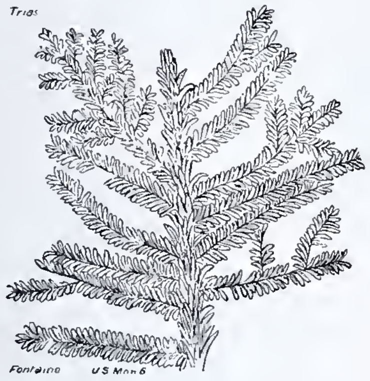
Palissya carolinensis, (*Pachypteris* Emmons


Trias
Font. Geol Sur. U.S. Mon. 6. Pl. 51. fig 5.

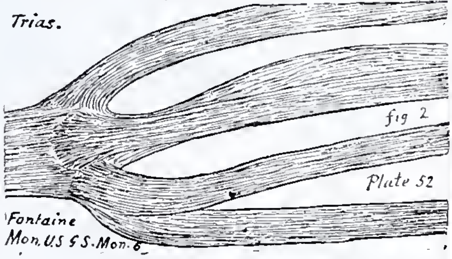
Pecopteris rarinervis, Fontaine



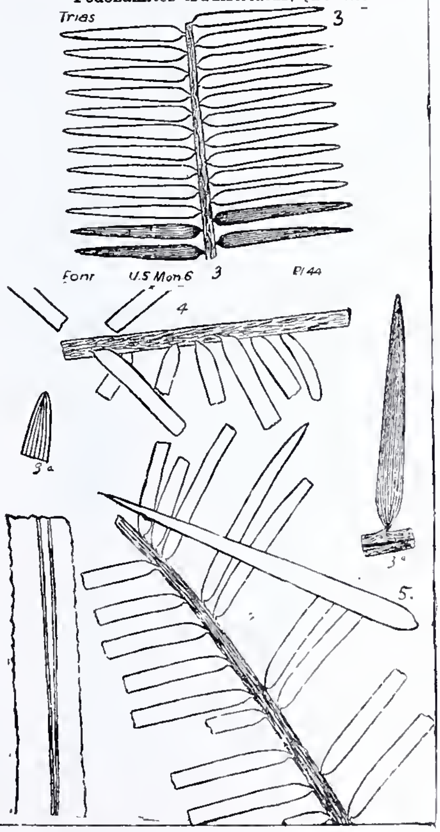
Palissya diffusa



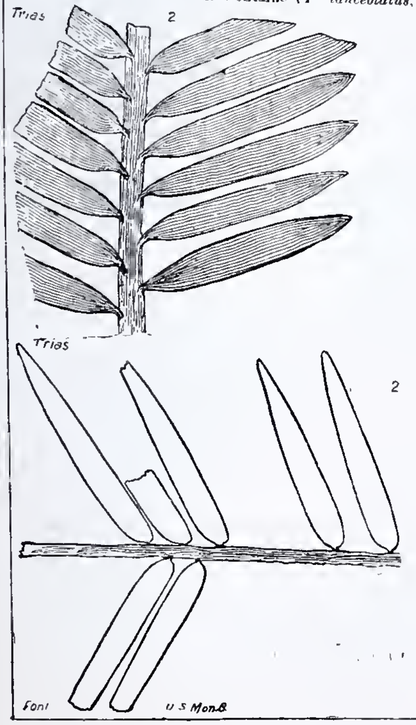
Plant of Triassic age, of unknown alliance Fontaine



Podozamites tenuistriatus, (*Zamites*

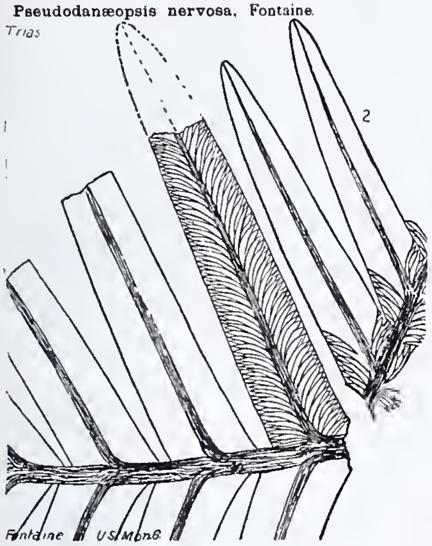


Podozamites emmonsi, Fontaine (*P lanceolatus*, Em



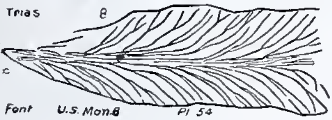
Mesozoic (Rhætic) plants of Virginia.

Pseudodanæopsis nervosa, Fontaine.



Trias

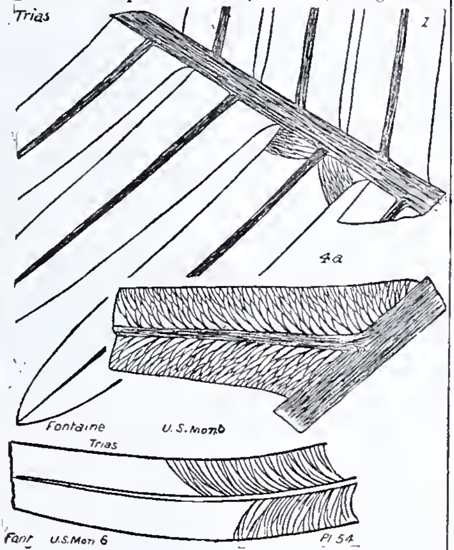
Fontaine U.S. Mon.6



Trias

Font U.S. Mon.6 Pl 54

Pseudodanæopsis reticulata, Fontaine, Monogr U S

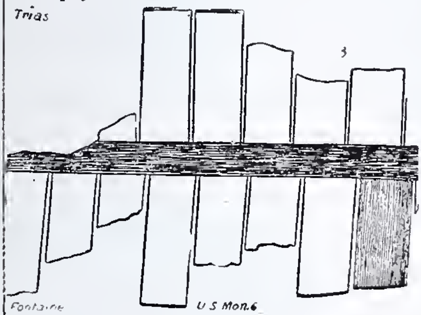


Trias

Fontaine U.S. Mon.6 Trias

Font U.S. Mon 6 Pl 54

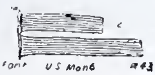
Pterophyllum affine, Nathorst Fontaine



Trias

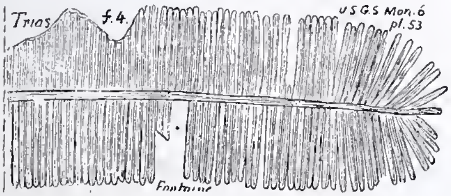
Fontaine U S Mon.6

Pterophyllum decussatum Emmons



Font U S Mon.6 Pl 43

Pterophyllum pectinatum. (*Pterozamites pectinatus.*)

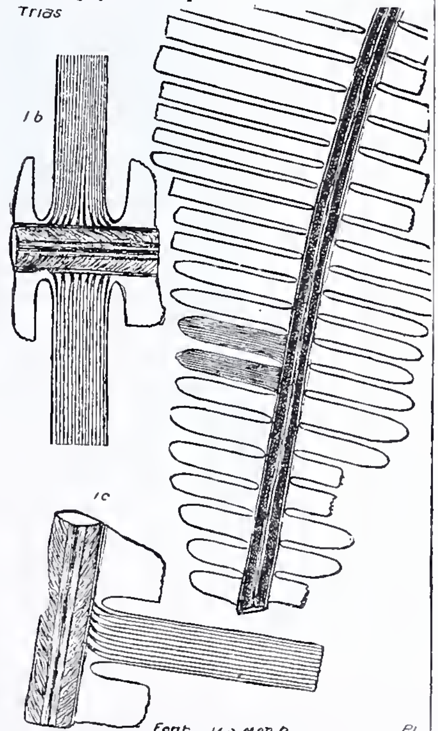


Trias

U S G.S Mon.6 pl. 53

Fontaine

(**Pterophyllum inæquale.**



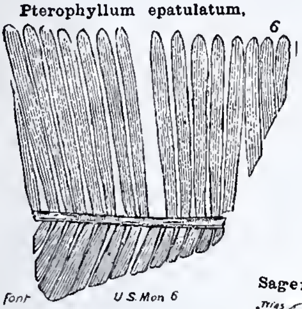
Trias

Font. U S Mon.6 Pl

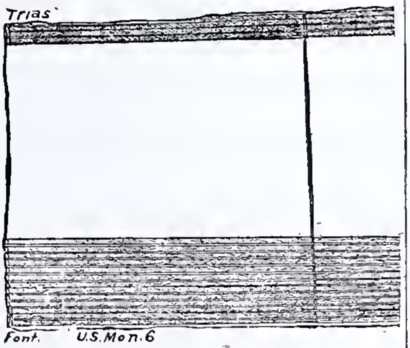
PLATE 606

Mesozoic (Rhætic, Connecticut) sandstone.

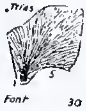
Pterophyllum epatulatum,



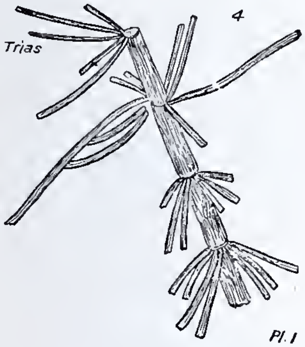
Schizoneura planicostata. 942



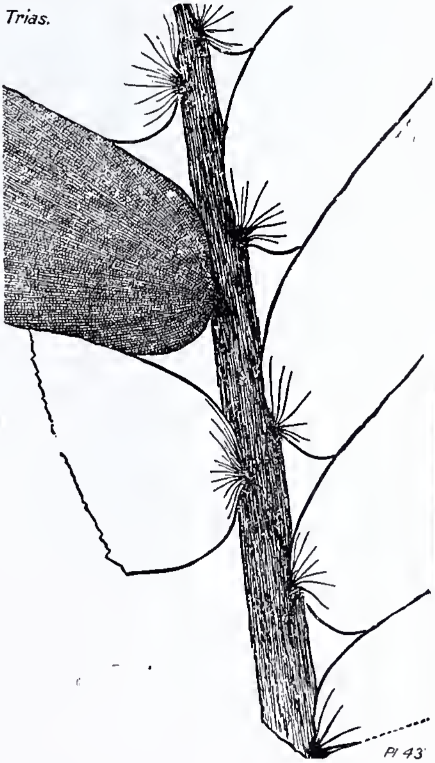
Sagenopterie rhoifolia ?



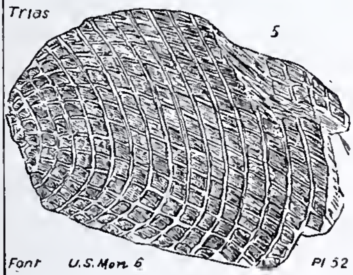
Schizoneura Virginieneie, Fontaine



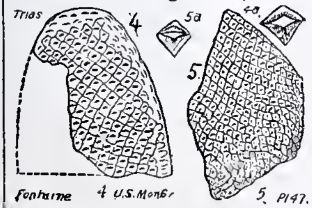
Sphenozamites rogereianue, Fontaine.



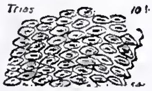
Zamiostrobus emmonsi, Fontaine,



Zsmioetrobus virginiensis, Font.

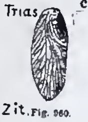


Zsmiostrobue —— ? Emmons.

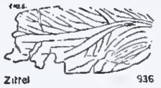


Mesozoic (Rhœtic, Trias, Connecticut) SS.

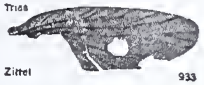
Neorthroblattina rotundata cockroach wing;



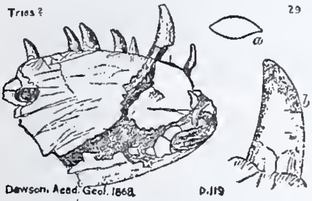
Poroblattina lakesii, Scudder.



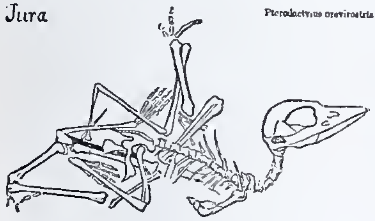
Spiloblattina gardneri, Scudder



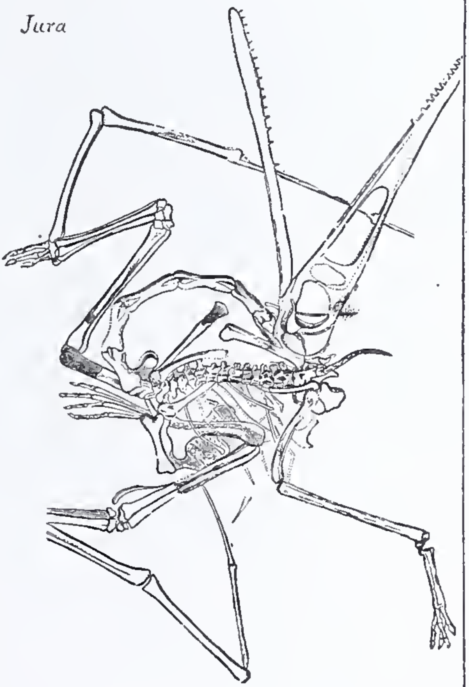
Bathygnathus borealis, Leidy, Proc. Ac



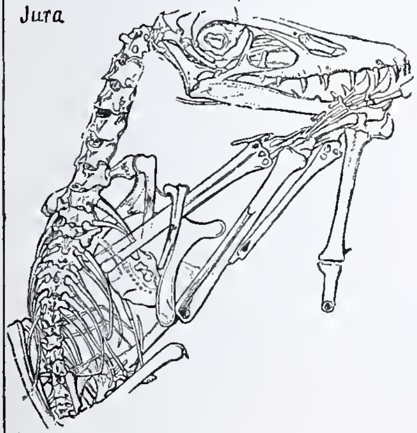
Pterodactylus brevirostris, Cuvier



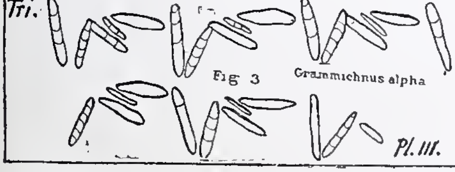
(**Pterodactylus longirostris**

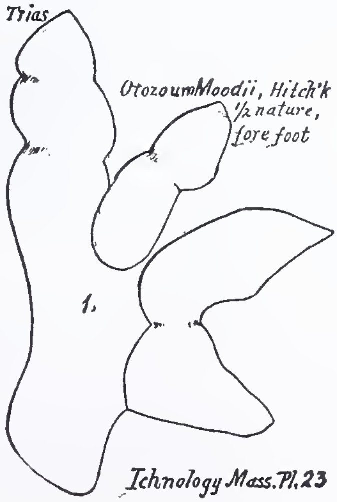


Pterodactylus crassirostris, Goldfuss



Tracks of *Grammichnus alpha*, Hitchcock. Supplement



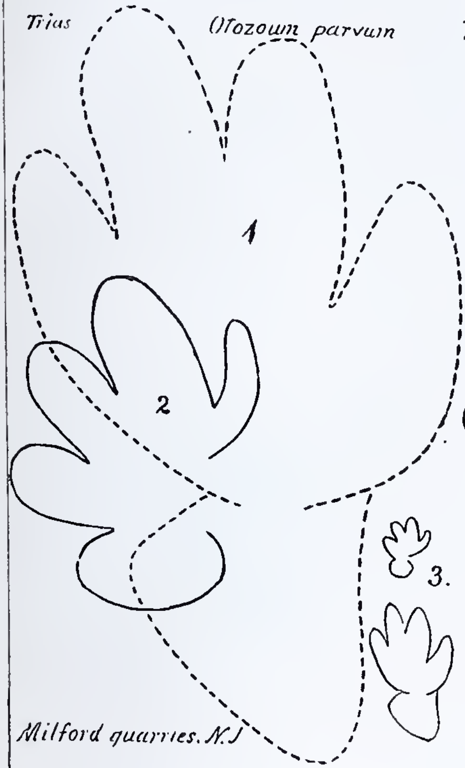


Otozoum Moodii, Hitch'k
½ nature,
fore foot

Ichnology Mass. Pl. 23

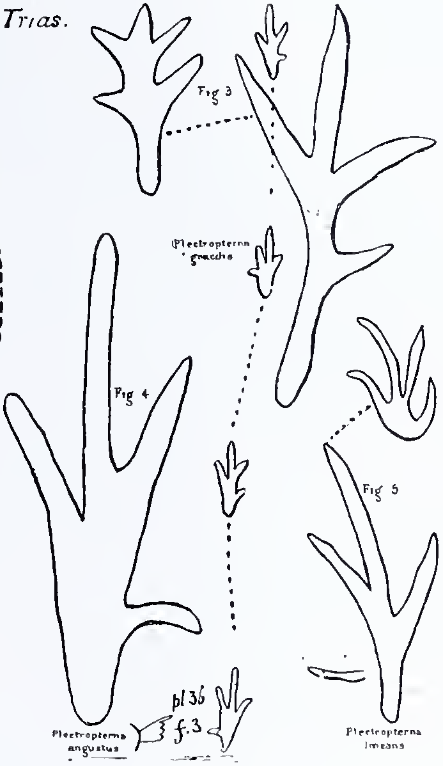
PLATE 608

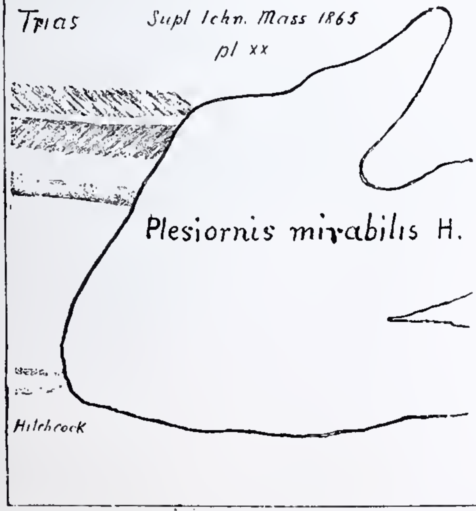
Mesozoic (Connecticut) sandstone tracks



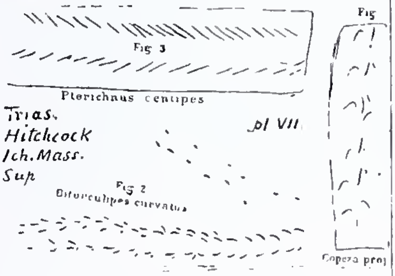
Plectropterns angusta, Hitchcock,

Trias.

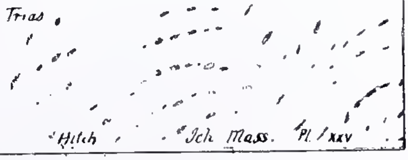




Pterichnus centipes, *Acanthicnus tardigradus*)

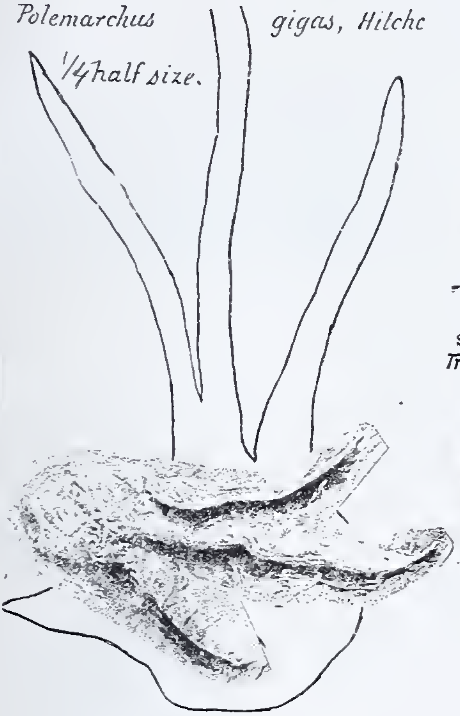


Ptilichnus anomalus, Hitchcock



Triassic reptile tracks &c. Massachusetts.

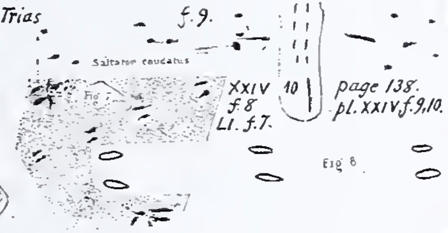
Polemarchus gigas, Hitchc


1/4 half size.

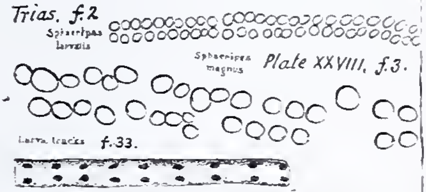
Ptilichnus pectinatus, Hitch. Ich. Mass., 1858.

Sagittarius alternans, *tracks*. Hitchcock, Suppl to Ich

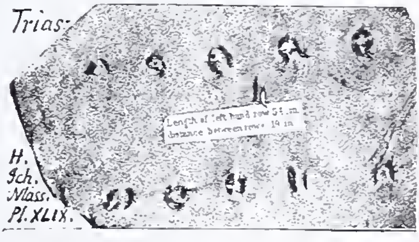
Saltator bipedatus, *tracks* Hitchcock. Ich. Mass. 1858



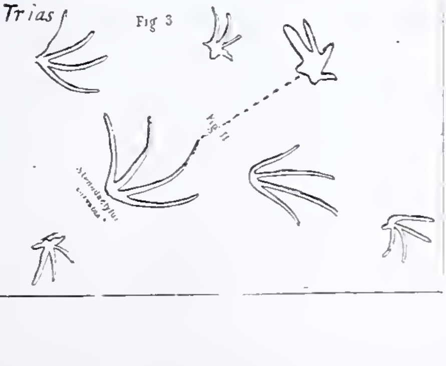
Sphæripes larvalis, *tracks*. Hitchcock. Ichn. Mass.



Stratipes latus, *tracks*. Hitchcock, Ich. Mass. 1858,


Trias:
Length of left hand row 54 in
distance between rows 19 in
H. Ich. Mass. Pl. XLIX.

Stenodactylus curvatus, *tracks*. Hitchcock, Ich. Mass



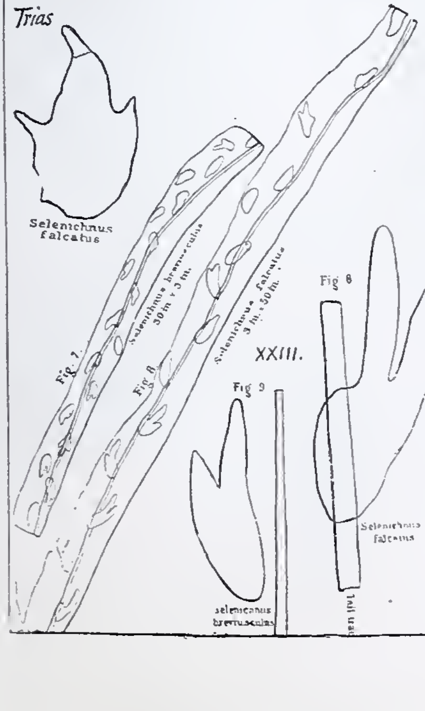
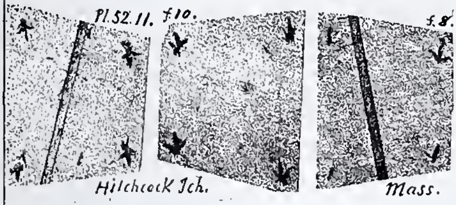
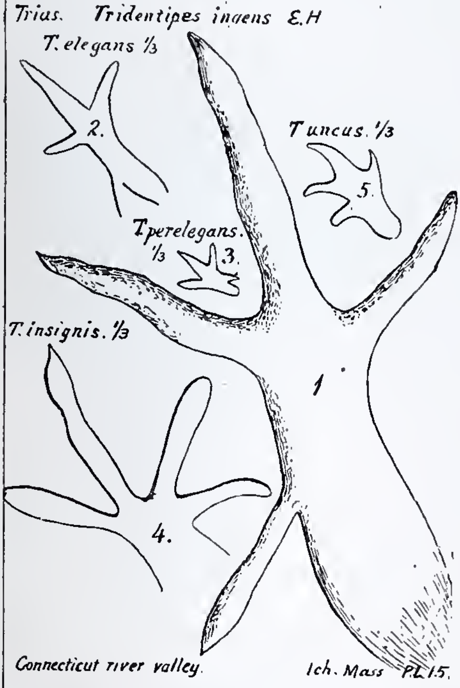


PLATE 610

Triassic reptile tracks. Amherst Museum.

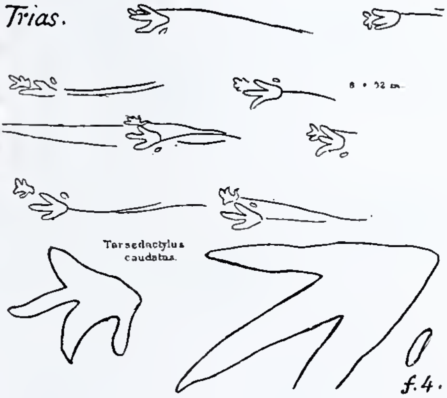
Tridentipes elegans. (*Steropezoum elegans; Ornithich*



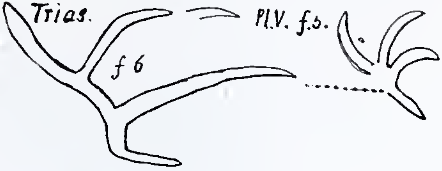


Tridentipes perelegans (*elegantior.*) Edw. Hitchcock, Ich

Tarsodactylus caudatus *tracks.* Hitchcock. Ich. Mass.



Toxichnus inæqualis, *tracks.* Hitchcock. Supplement



Triænopus leptodactylus.

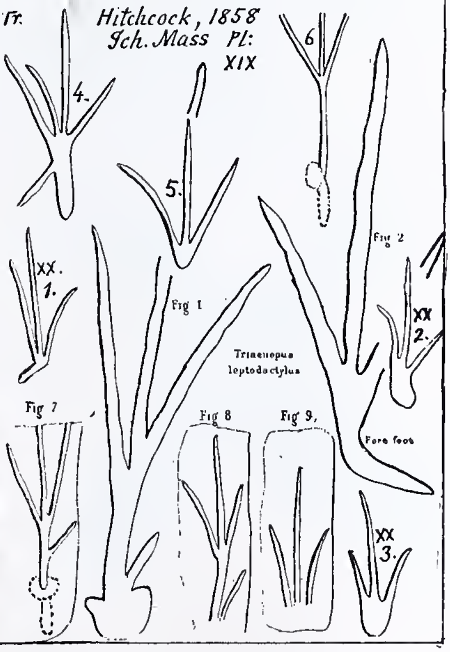
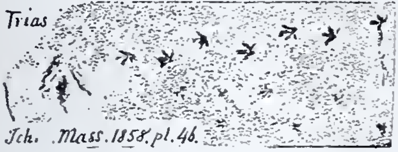


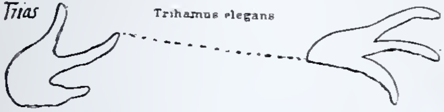
PLATE 611

Triassic reptile and worm tracks, and fishes.

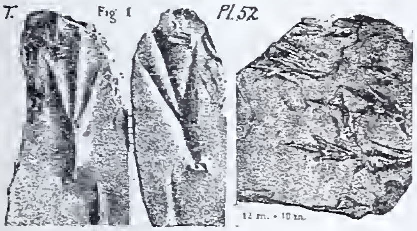
Tridentipes uncus, Ed. Hitchcock, Ichnology



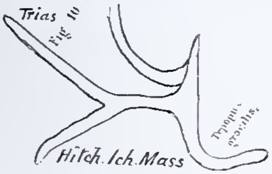
Trihamus elegans, *tracks.* Dr. E. Hitchcock. Supplement



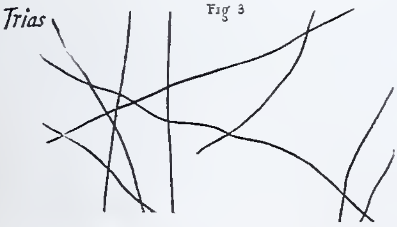
Triænopus leptodactylus.-



Typopus gracilis.

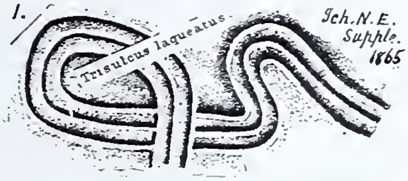


Unisulcus minutus, *worm? track.* Hitchcock Ich

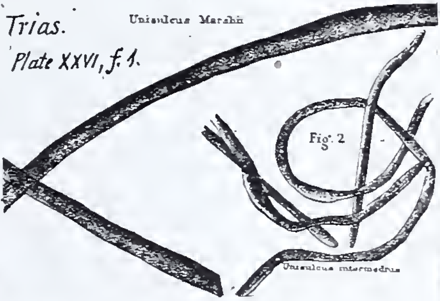


Clepsysaurus pennsylvanicus.

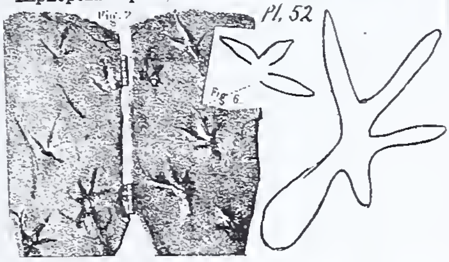
Trisulcus laqueatus, *worm track.* E. Hitchcock.



Unisulcus intermedius, *track.* Hitch. Ichnol. Mass. 1858



Xiphopeza triplex, track. Hitchcock. Ich



Ptycholepis marshii, Newberry.